VOL IV PART V

THE

INDIAN FOREST RECORDS

Note on the Utilization of Bamboo for the Manufacture of Paper-pulp

By

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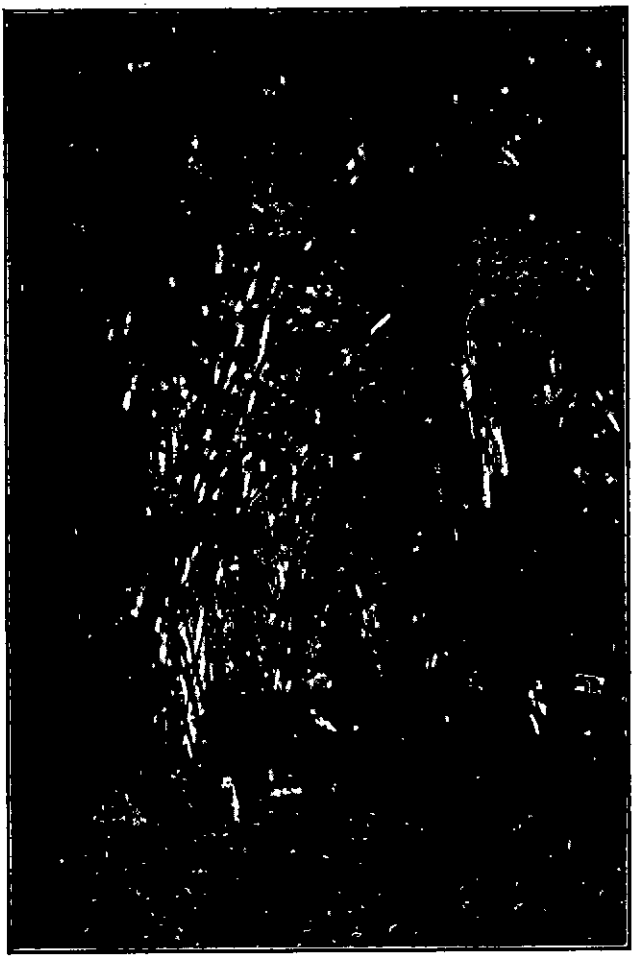
Pearson.—Utilization of Bamboos in the Manufacture of Paper-pulp.



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Bambusa polymorpha Forest in the Pyinmana Division, Upper Burma.

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INTRODUCTION.

THE idea of manufacturing paper-pulp, from the raw material available from the forests of India, dates back nearly fifty years, though the only one of the many fibre-yielding plants available and now in common use for this purpose is Sabai grass (*Ischæmum angustifolium*). The possibility of manufacturing pulp from other Indian species is fully recognised, but, so far, the commercial world has considered the data available on this subject insufficient to justify starting work with those fibres. When the enquiry of which this report is the outcome was commenced in 1908, the idea was to investigate the possibility of manufacturing pulp from both timber and bamboos. As the work of getting together the necessary information proceeded, it was found that the collection of reliable data on both subjects at one and the same time was not practicable, as by so doing the enquiry would become too lengthy and complicated. It was, therefore, decided to take up bamboos as a commencement and to leave the woods until fair progress had been made with the enquiry concerning the former species. This report, therefore, deals with bamboos only.

A further restriction was also placed on the bamboo enquiry. It was thought advisable to restrict the area over which examination of the

forests should be made and to visit only a few of the most suitable localities for the purpose of collecting the necessary information. It must, therefore, be clearly understood that, though the forests, which are described in this report and which are shown on the maps, are favourable localities, from which bamboos can be extracted at cheap rates and are geographically well situated for that purpose, they are by no means the only places in British India in which it would be possible to work a pulp-mill at a profit.

Some explanation is necessary as to the limited scope of this enquiry, as regards locality. Up to date no firm or company has taken up the manufacture of pulp from bamboos in this country, and the object of this enquiry is to try and induce a firm to do so, as it is thought that if a commencement is once made and if the experiment proves, or clearly promises to be commercially successful, an industry of considerable importance may well be established. With this object in view, a limited number of localities have been chosen, which are considered suitable for the purpose, and about which definite information is given in this report.

The places selected for examination were Lower Burma and the West Coast of the Indian Peninsula, as both localities are geographically well situated for import and export purposes and also contain vast areas covered with bamboos. In Burma five localities were visited of which a careful inspection was made, namely, the Rangoon, Tharrawaddy, Pyinmana, Toungoo and Arakan Divisions. In Bombay three were inspected, namely, one partly in the North and partly in the West Kanara Forests Divisions, a second entirely in the Western Division and a third in the East Kanara Forest Division. In Madras a similar number were selected, namely, one in the South Canara Division, and one in each of the North and South Malabar Forest Divisions. The report, therefore, deals with five possible areas, from which bamboos could be exploited for the purpose of manufacturing pulp in Burma, and six on the West Coast of India.

In 1905 the Government of Burma invited Mr. R. W. Sindall, F.C.S. (London), a paper-pulp expert, to visit that country with a view to enquiring into the possibility of manufacturing paper-pulp. His report on the subject appeared in March 1906, and is one of great value. In it he laid down the lines along which further enquiry should be made, and it is largely on his proposals that the present enquiry has been based.

The writer of this report, with a view to collecting further information as to the lines on which the enquiry should be carried out, visited three of the largest paper-mills in India, and by the courtesy of the Managers of those mills, was able to ascertain what further data would be required by pulp manufacturers before they would consider the possibility of starting a mill in which bamboo would be used as the raw material. Their chief difficulty was the want of definite information as regards localities from which a large sustained yield of bamboos could be obtained at cheap rates and the possibility of manufacturing a fixed grade of pulp within a workable figure of cost. Messrs. Sindall and Raitt have proved, by their laboratory tests, that fair pulp could be made from bamboos, but the information as to supply, cost and grade of pulp when worked on commercial lines still remained to be collected.

To overcome these difficulties, the areas above mentioned were carefully inspected and extensive countings and weighings of bamboos carried out to obtain figures of yield, while to obtain a practical proof of the quality and cost of preparing pulp from bamboos, about 80 tons of raw material, of four different species of bamboos, were sent to the Titaghur Paper Mills and through the good services of the Managing Agents, Messrs. F. W. Heilgers of Calcutta, the whole was converted into pulp and eventually into paper.

The writer of this report also wishes to acknowledge the help which has been given him by various officers of the Forest Department, firms and private persons, without whose assistance it would have been quite impossible to carry out the enquiry.

While touring in various Provinces of India and in Burma he received the greatest help and kindness from all Forest Officers; it is impossible for want of space to mention more than a few of these officers by name. Amongst those who rendered the greatest assistance were Messrs. M. Hill, C. G. Rogers, F. A. Leete, G. E. S. Cubitt, J. J. Rorie, H. L. P. Walsh, H. C. Walker, C. H. Philipp, J. V. Young, G. H. Alington and E. M. Buchanan in Burma; Messrs. T. R. D. Bell, L. S. Osmaston, W. E. Copleston, A. G. Edie, W. A. H. Miller and G. S. Butterworth in Bombay; and Messrs. F. A. Lodge, G. F. F. Faulkes, D. T. Barry and A. Wimbush in Madras.

Mr. Coventry, formerly Imperial Forest Chemist, carried out laboratory tests with bamboos at the Forest Research Institute, Dehra Dun, and further laboratory tests, the results of which are given

in his separate report on this subject, have since been carried out by Mr. W. Raitt, a pulp expert, to whom the writer is indebted for much help and advice.

Through the courtesy of Messrs. F. W. Heilgers, Managing Agents to the Titaghur Mills, it has been possible to have tests carried out with bamboos on a commercial scale, and it is largely due to the interest taken by them, especially by Messrs. Bryce, the General Manager of the Titaghur Paper Mills, and J. Thomson of that firm and to their report on the tests carried out by them that it has been possible to complete this enquiry. Acknowledgments are also due to Messrs. Balmer, Lawrie & Co., of the Bengal Paper Mills, for allowing the writer to visit their mills at Raneegunge and for affording him valuable information as to the present position of the pulp industry in India.

Lastly, the writer has to acknowledge, with thanks, many reports from various Forest Officers all over India, many of which contained valuable information as to possible outturn of timber and bamboos from their divisions, and though much of it does not find a place in this report, it is ledgered in the office of the Forest Economist at Dehra Dun and it will, without doubt, be of the greatest value later on, should the pulp industry develop in India.

PART I.

GENERAL DISCUSSION ON THE SUBJECT.

1. History of former enquiries carried out with a view of ascertaining the possibility of manufacturing paper-pulp from Bamboos.

Origin of the enquiry.—The idea of manufacturing paper-pulp from bamboos is not a new one. During the early seventies of the last century, Esparto grass was chiefly in use for the manufacture of paper, and just about that time the demand for cheap paper began to exceed the available supply of this grass. Paper-pulp manufacturers were therefore on the look-out for suitable substitutes and amongst others which came under their notice were conifer woods and bamboos. The conifer woods won the day, being obtainable nearer the European market, so that to-day at least three-fourths of the world's supply of paper is made from spruce and pine woods. The bamboo, however, during that period, received a fair amount of attention. The Government of India instituted an enquiry in 1873, the report on which deals with possible fibre-yielding plants, their strength and general qualities.

Enquiry by Hem Chandra Kerr in 1874.—The next publication on the subject of Indian fibres is by Babu Hem Chandra Kerr, entitled "The Cultivation of Jute in Bengal, and on Indian Fibres available for the Manufacture of Paper."

T. Routledge's enquiry of 1875.—We next find an Englishman, namely, Mr. Thomas Routledge of Sunderland, taking an interest in bamboos, at just about the time of the crisis when the supply of Esparto grass was becoming insufficient to meet the demand. It may be said that it was to this gentleman's initiative that bamboos began to be seriously thought of as a possible raw material from which to manufacture paper-pulp. He published two notes on the subject, one in 1875, entitled "Bamboo considered as a Paper-making Material" and another entitled "Bamboo and its Treatment" which appeared in 1879.

Liotard's Report of 1883.—In 1883, Mr. Liotard published a note on "Paper-making Industry in India" which deals directly with the consumption of paper in India and the United Kingdom and discusses Railway Rates, which do not, however, apply at the present time.

E. E. Fernandez's Report of 1890.—About 1890, there appeared an article in the "Indian Forester" by Mr. E. E. Fernandez, late Conservator of Forests, entitled "Wood Cellulose and Wood-pulp," in which he describes the various methods of preparing wood-pulp, especially those in vogue in French mills. The article is most instructive as explaining the methods of preparing pulp by the mechanical and soda processes.

Articles in the "Indian Forester."—Many articles have appeared from time to time in the "Indian Forester," notably two by Mr. Clutterbuck in 1899 and 1900, in which estimates are given as to the working of a mill using Himalayan conifers.

Report by S. Chas. Philipps of 1905.—In 1905, Mr. S. Chas. Philipps, M.S.C.I., read a most able article before the Society of Arts, London, on the subject of the manufacture of mechanical and chemical paper-pulp, in which he describes the various processes and their origin.

R. S. Sindall's Report of 1906.—It is not, however, until we come to Mr. Sindall's report on the "Manufacture of Paper and Paper-Pulp in Burma" that we find really definite information regarding the possibility of preparing pulp from bamboos and Indian woods. His report is divided into two parts, (i) Bamboos, and (ii) Woods. It is with the former that we are here concerned. Under Bamboos he has collected information regarding the weight of green and dry bamboos, the percentage of nodes to internodes, the size of the various species of bamboos, their market value in different places and the cost of extraction from various localities to a possible factory site. He also carried out tests by the soda process on a laboratory scale, and further tests for bleaching. He ends this report by proposing possible factory sites and discusses freights and cost of chemicals. His report is of great value and the present enquiry has been based on his suggestions as to the lines on which future investigation on this subject should be carried out. In 1909, he prepared a second note on the same subject, entitled "Bamboo for Paper-making," and this report is printed on paper made from bamboo pulp.

G. F. Richmond's Report of 1906.—A series of pamphlets have been issued by Mr. George F. Richmond of the Bureau of Science, Manila, on the subject of paper-making. The first is entitled "Philippine Fibres and Fibrous Substances: their suitability for Paper-making" Vol. I, No. 5 of June 1st, 1906. The next is Part II, of the same publication,

Vol. I, No. 10, December 1906, which treats chiefly with bamboos, and Part III (conclusion), Vol. II, No. 2, Section A, May 1907.

W. Raitt's Report of 1909.—The latest articles which are to hand on this subject appeared in "Tropical Agriculture" in 1909, under the signature of Mr. W. Raitt, a pulp expert, in which he discusses the sulphite process, as compared with the soda process, in manufacturing pulp from bamboos. In another pamphlet by the same author, in the "Paper Trade Review" of 1907, is given very useful information collected by him from sample plots taken in bamboo forests, from which figures of yield are calculated. Also interesting are the experiments made by him at the Bengal Paper Mills, Ltd., which go to confirm Mr. Sindall's tests carried out by the soda process, when that gentleman was in Burma. Raitt went further than Sindall and carried out tests on bamboo by the sulphite process, but the latest results obtained by Messrs. Raitt and Coventry in India and Mr. Richmond in Manila, go to prove that bamboo sulphite pulp is difficult to bleach. His further report on this subject entitled "Report on the Investigation of Bamboo as Material for Production of Paper-pulp" is the outcome of his experiments carried out at the Forest Research Institute, in which he describes the treatment of bamboos by the Soda and Sulphate processes. He also deals with the subject of treating the nodes together with the internodes, and the treatment of bamboos before boiling. This enquiry has been made conjointly with this report and is worthy of very careful perusal.

1908 and 1909.—In 1908, there appeared three Government publications on the subject of paper-making in India. One was by Mr. R. T. F. Kirk, I.C.S., entitled "A Monograph on Paper-Making in the Bombay Presidency" which deals chiefly with hand-made paper. Another is by Mr. D. N. Mookerji, M.A., on "Paper and Papier-Maché in Bengal" and a third bearing the same title, but dealing with the Punjab, by Mr. H. W. Emerson. In 1909, a fourth monograph also bearing the same title as the above publications, was published by Mr. J. N. Gupta, I.C.S., which deals with paper-making in Eastern Bengal and Assam. Not one of these four publications throws any light on the manufacture of paper from bamboos: they deal chiefly with hand-made paper.

There is a large amount of miscellaneous literature available on this subject, often of a very instructive nature, which has appeared in various Indian newspapers and periodicals, none of which, however, deals so intimately with the subject of bamboos as do the various reports and

articles published from time to time by Messrs. Sindall, Raitt and Richmond.

2. Present condition of the paper-pulp trade in India.

Materials used for paper-making in India.—At the present day paper is made of either waste materials such as rags, old rope, gunny bags, waste paper, etc., or from raw material such as grass, reeds, straw, wood, etc. By far the greater portion is, however, manufactured from either rags, waste paper, grass or wood. In India the chief raw material used is a grass, known as Sabai or Baber (*Ischæmum angustifolium*), which is obtained from the forests of Bengal, Orissa, Nepal and the United Provinces. No chemical or mechanical wood-pulp is made in this country though considerable quantities are imported by the existing paper-mills. The other materials used in India for the manufacture of paper are rags of poor quality, hemp, jute, gunny bags, waste paper and old rope.

Present position of affairs.—Much has appeared of recent years in periodicals and newspapers in India on the subject of the world's supply of paper. Without doubt the demand is extremely large, the present outturn according to Raitt being about 8 million tons, of which about half is produced in Europe and the remainder in America. The quantity of raw and waste material necessary to produce this amount of paper must be enormous. It is said that at least 6½ million tons of paper are produced from spruce and pines in Northern Europe, America and Canada. It is, therefore, on timber that the world at present relies for its principal supply of paper, and the question naturally arises whether the supply of timber is sufficient to meet the ever-increasing demand. The answer is without doubt in the negative. The supplies from Norway, Sweden, Denmark and Russia are not yet exhausted but already many warning notes have been sounded in that direction. The time must therefore come when the supply will run short, for in spite of strict protective measures which have been taken to ensure the preservation of the forests, the annual outturn is now in considerable excess of the possible sustained yield. Similarly, the United States have taken warning and their Government recently appointed a Commission to enquire into the subject of the supply of raw material for paper. Their report points out that matters have already gone far and proposes measures of economy. Canada still contains a vast amount of timber, but experience has

shown that no forests are really inexhaustible. History is therefore repeating itself in the matter of the supplies of the raw materials for the manufacture of paper. The first instance was when the amount of rag available was insufficient and Esparto grass came in during the fifties to save the situation. A similar difficulty arose in the seventies and this time the situation was saved by the introduction of spruce wood-pulp. Again in 1910 the position became acute. It is true that the prices of chemical wood-pulp have not as yet shown any startling upward tendency, but the continuous fall in prices of both wood-pulp and the paper made from it, came to a sudden stop five years ago, while the absence of any serious rise in prices is due to the stress of competition in the producing countries. It is believed in paper-making circles that these conditions cannot continue, and that prices must inevitably rise in the near future as the ever-increasing shortage of wood makes itself more seriously felt.

Mr. A. D. Little, Chief Scientific Officer to the American Paper and Pulp Association, in a report on this subject, emphasises "the growing scarcity of pulp wood, the continually rising price and longer haul with which paper-makers using this material are now contending, and the coming competition of new and better stocks which even now can be produced more cheaply than any bleached wood fibre."

"Wood, as a raw material, has proved so available, convenient, compact, easily handled, and heretofore so cheap, that we have been led to overlook or ignore the immense sources of other and better paper stocks which lie easily within our reach.

"We are not dealing with the perennial suggestions of visionaries who see a paper stock in every thing which has a fibre, but are instead, concerned with the serious proposals of capable technologists whose conclusions are based on careful study."

History of paper-mills in India.—The first paper-mill in India was erected at Serampore and is reported not to have been a success. The next venture was that made by the Bally Paper Mills Company in 1874; for ten years it flourished; after that it did not pay and finally went into liquidation in 1906.

At present there are six or seven paper-mills in India. The largest is the Titaghur Paper Mills Co., Ltd., with two mills near Calcutta, the older mill being situated at Titaghur and the newer mill at Kanknarrah. Their present outturn is about 14,000 to 15,000 tons of

paper per annum, made of Sabai grass, imported spruce wood-pulp and a limited amount of jute, hemp and rags.

The next most important paper-mill is situated at Raneegunge on the East Indian Railway, some 120 miles from Calcutta which belongs to the Bengal Paper Mill Co., Ltd. Their paper is made of the same materials as at Titaghur and the outturn is about 6,700 tons per annum.

Another large paper-mill exists at Lucknow, known as the Upper India Couper Paper Mills, Ltd. The raw material used in this mill is also grass, but old rags, waste paper, jute, gunny bags, and hemp here play a larger part in the manufacture of paper than is the case in the other mills.

The fourth mill of any size in India, is in the Western Presidency, at Poona, and is known as the Deccan Paper Mill Co., Ltd. The materials used in this mill are the same as elsewhere in India, though Sabai grass does not appear to play so prominent a part as in Bengal mills. The outturn is stated to be 1,000 tons of paper per annum.

A few smaller mills exist in India and a certain amount of hand-made paper is manufactured, but the total outturn of this grade of paper is not sufficient to seriously affect the market.

Imports and exports of paper in India.—The exports of Indian made paper and paste boards are at present practically *nil*. It is not impossible, however, that this state of affairs may one day be changed, when it is considered that enormous quantities of raw material suitable for the manufacture of paper, but not as yet utilized, are available in the forests of India and Burma. At present we are only concerned with the imports of paper and the outturn of the existing Indian paper mills; the question of exporting half-stuff or paper from India may come later, but the question of supplying the existing market is the one which is at present attracting the attention of the Indian paper-makers.

The value of the imports during the last five years was as follows :—

Class of paper imported.	1905-06.	1906-07.	1907-08.	1908-09.	1909-10.
	Rs.	Rs.	Rs.	Rs.	Rs.
Printing paper . . .	21,32,459	28,33,632	36,26,984	30,96,000	33,18,292
Writing paper and Envelopes	19,15,114	22,66,714	28,09,522	23,83,354	25,53,561
Other kinds of paper . .	26,49,757	25,75,366	31,42,264	33,39,036	37,43,901
Paste, Mill and Card boards of all kinds.	3,51,648	3,35,393	3,45,492	4,45,005	5,14,495
TOTAL . .	70,48,978	80,11,105	99,24,262	92,63,396	1,01,30,249

From the above figures it will be seen that the imports have increased to the value of 31 lacs of rupees in the last five years. The most steady increase comes under "Other kinds of paper," namely, the paper which finds its way into the bazar, and it is against this imported paper that it is hoped that the Indian paper-mills will be able to compete with the help of bamboos as a raw material.

To arrive at a definite conclusion as to the relative position of affairs it is necessary to compare the present outturn from Indian mills with the amount imported into this country. The figures for the last five years are as under :—

Year.	Produced in India.	Imported.
	Rs.	Rs.
1905-06	51,86,729	70,48,978
1906-07	63,10,940	80,11,105
1907-08	72,90,385	99,24,262
1908-09	75,87,267	92,63,396
1909-10	79,11,943	1,01,30,249

It will be seen from the above statement that though the amount produced in India shows a steady increase amounting to 27 lacs of rupees in five years, the imports show an increase of 31 lacs during the same period. Again the Indian made paper amounts to 44 per cent. of the total consumption against 56 per cent. of imported paper, so that there is ample room for the further development of the Indian product, provided it can be put on the market at a somewhat lower rate than at present. There is yet another factor in favour of the Indian paper-maker. Merchants purchasing imported paper have to take up large consignments at one time and pay on delivery. This is often an inconvenience to traders, who naturally object to investing large sums of money in a commodity which does not improve by keeping and which they cannot dispose of quickly, so that when paper can be purchased for retail purposes in smaller quantities, as is possible from Indian mills, they can afford to pay up to 10 per cent. higher prices for the same article

than it is possible for them to do for large quantities of the imported material.

Cost of paper in India.—The number of grades of paper found on the Indian market is very large and market values vary considerably. The following may be taken to be the present average wholesale rates in the Calcutta market of the grades most likely to be affected by the introduction of a better supply of raw material :—

Writing paper	Rs. 400 per ton.
Superior printing paper	Rs. 330 „ „
Common „ „	Rs. 290 „ „
Half bleached paper	Rs. 280 „ „

From the published financial results of the companies concerned during recent years, it is clear that these prices carry a margin of profit so small that a very slight adverse disturbance of the prevailing conditions would wipe it out altogether. In the opinion of Mr. Raitt, who knows the mills well, this unfortunate state of affairs is not in the least due to deficiencies in the equipment of the mills or in their organisation and management, but solely to the lack of an adequate supply of cheap raw material.

State of Indian paper market.—To compete with the low prices of imported bazar paper it is necessary to produce a pulp at cheaper rates than can now be done with Sabai grass, mixed with a certain amount of imported wood-pulp, so that some other raw material must be found as a substitute, and from the trials recently carried out on a commercial scale it is believed that bamboos will answer the purpose.

There is another factor to be considered in connection with the price of the better classes of paper as supplied to Government and large firms by the Indian paper-mills, and that is that the cost at which Sabai grass paper can be supplied, is now so high that it is nearly possible to import equally good paper made of Spruce pulp treated by the sulphite process. In other words, the Indian high class papers are in danger of being undersold by equal grades of imported spruce paper. It is understood that this has already occurred in Madras, and that that Government have given up their Indian contracts and taken to European-made paper. This is an extremely serious state of affairs for the Indian paper-makers.

The Indian paper-maker has therefore two interests at stake, one is to keep down the cost of manufacturing his better grades of paper so as not

to lose his present market for that commodity, and the other is to reduce the cost of production of his cheaper grade papers so as to enable him to compete successfully against the imported "News" and Bazar paper. It is hoped that it will be possible to do this with the help of bamboo-pulp.

3. General conditions necessary for the successful establishment of a paper-pulp mill.

The conditions necessary for the successful establishment of a paper-pulp mill are manifold, and can only be found in a few localities. Even in the most favourable localities some factors of minor importance, though none the less necessary, are often absent, so that the best that can be done is to choose a locality where the most important conditions to ensure success are to be found.

Conditions necessary for the establishment of a mill.—The most important conditions necessary may be summarised as follows :—

(1) That a sustained annual yield of a suitable raw material for the manufacture of pulp be available in abundance.

(2) That the cost of extraction of the same can be kept within economic limits for many years to come. For bamboos the maximum price is put at Rs. 15 per ton of dry internodes landed at the mill, but it should, generally speaking, be less. By treating the nodes also, the price can be reduced by 7 to 15 per cent., according to species, as that amount of waste will be saved by utilizing the nodes.

(3) That the raw material should have little or no local value or should be available in such quantities that the requirements of a mill do not interfere with the local demand and prices.

(4) That the crop from which the raw material is drawn be a close grown one, in other words, gregarious, so that the cost of collection, and the area over which supervision is necessary, be reduced to a minimum.

(5) That the factory site selected be such that the raw material can be floated down stream to the mill door. Further it is necessary that there be direct communication by river between the mill and sea-port in order to import the necessary chemicals and coal and export the manufactured pulp. It is

preferable that the lead from the forest to the mill and from the mill to the sea-port be as short as possible though the latter is the more important factor of the two.

(6) That lime be available at cheap rates and in large quantities.

(7) That a plentiful supply of fresh water be available.

(8) That labour in sufficient quantities be forthcoming to carry out the work of extraction and to run the mill.

(9) That the locality be reasonably healthy.

(10) That the river be not subjected to excessive floods.

In the above list of conditions nothing has been said about the sale of the manufactured produce, as it stands to reason that, provided a fair quality of pulp can be put on the market at a sea-port at a reasonable cost of production, the only limit to its sale is the economic distance to which it can be exported. As an illustration of the above, the following case may be quoted. Supposing it is possible to land a certain grade of bamboo-pulp in Rangoon at £6 per ton, it might pay to export it to Calcutta or Madras, but not to Europe, or again it might be possible to export it to Japan, in competition with European pulps now imported into that country.

From what has been said above, it will be understood that the number of localities in India and Burma which fully meet all these conditions must necessarily be limited. It is thought that certain places in Lower Burma do so, such as areas on the eastern and western slopes of the Pegu Yomas, which drain into the Sittang and Rangoon or Myitkara rivers, respectively. Again certain localities in Arakan and possibly along the Chittagong and Orissa coasts are suitable, and lastly the Malabar Coast, with its many perennial streams running down to the sea from the teak and bamboo forests of the Western Ghats.

The separate cases which have been drawn up for these various localities in India and Burma are given in Part IV of this report, and are the result of careful inspections and enquiries made on the spot and based on the necessary conditions enumerated in the foregoing paragraphs.

PART II.

BAMBOOS, THEIR MODE OF GROWTH AND THE POSSIBLE OUTTURN.

1. Species of bamboos.

Bambusa arundinacea—the Daugi bamboo of Kanara—occurs throughout the Peninsula and is found at its best in the moist forests of the Western Ghats. In the latter locality it grows to a great size, often being found 100 ft. in height and each culm of great weight. A peculiar feature of this species is that it forms a dense palisade of small armed lateral branches round the base of the clump. This palisade reaches often 6 to 8 ft. upwards from the ground and makes extraction, looking to the weight and size of the culms, an expensive and difficult matter. Another drawback to this species is the thickness of the stem-walls and the hardness and size of the nodes. On the other hand, the local wood-cutters, who are used to dealing with this class of bamboo, are quite capable of carrying out its extraction, and though the cost of doing so is relatively high per culm, their great weight compensates for the extra expenditure, so that the actual cost of collecting one ton of dry bamboo works out to about the same as that of the lighter and more easily handled species found in Burma.

Bambusa polymorpha—the Kyathaung bamboo of Burma—is one of the commonest species found in the Pegu Yomas. The culms grow to nearly as large a size as those of *Bambusa arundinacea*. They are, however, unarmed, and do not grow in so compact a mass, besides which, owing to their relatively thin walls and small nodes, they are much more easily handled. They have therefore, in all points, the advantage over the larger species, when considered in connection with the pulp industry, except that they do not yield the same quantity of raw material per culm.

Cephalostachyum pergracile—the Tinwa bamboo—is also a Burma species, found in both the Upper and Lower provinces. In the Pegu Yomas it is very plentiful, but not quite so common as *Bambusa polymorpha*. It is smaller in size than that bamboo, but, in other respects,

as far as the paper industry is concerned, it is quite as suitable for pulp as that species.

Melocanna bambusoides—the Wanwé bamboo of Arakan, Burma and Assam—is found throughout Arakan, the Surma and Assam Valleys and Chittagong. It has an entirely different habit to those above mentioned in that, instead of growing in clumps, it emerges from the ground at short intervals, each stem being at a considerable distance from the next. It is a small, unarmed, soft bamboo, rarely over 30 ft. to 50 ft. in height, weighing from 3 lbs. to 10 lbs. when dry, with thin walls and small nodes. A full description of its mode of growth is given in Part IV of this report.

2. Bamboo as a fibre-yielding plant.

Bamboos come under the Natural Order *Gramineae*, to which order also belong the grasses. The fibres formed by the vascular bundles are extremely silky and fine and if seen under a microscope show fine barbs, an important factor in the "felting" and strength of pulp made of this material. The fibres in the internodes are arranged in regular parallel lines, with no tendency to be twisted or contorted, as is the case in certain species of timber, so that they can not only be split with great ease, but also be cut up into very regular sections. Another important point is that owing to the regular arrangement of the fibres and to the bamboo being hollow, the fibre can easily be reduced by crushing to a substance not unlike tow, an alternative method of treatment to cutting the bamboos before boiling which has been proposed by Raitt. That bamboos lend themselves to either of these methods of treatment is an important consideration in obtaining uniform digestion while boiling.

The suitability of bamboo fibre for the preparation of paper-pulp has been already fully demonstrated in former years by experiments carried out on a laboratory scale by various experts. The question of the quality and grade of paper produced by the various species of bamboos is fully discussed in Part III of this report.

3. Mode of growth of bamboos.

Mode of growth of Bamboos.—In order to determine the best methods of cropping bamboos in order to obtain the largest sustained yield, it is necessary to know something about the mode of growth of the various species. It might be said with justice that this information is out of

place in such a report, were it not for the fact that there appears to be doubt, in the mind of those interested, as to whether bamboo clumpa will stand repeated cutting.

Briefly, the mode of growth is as follows. The seed on germinating sends out a small shoot in the rains, completing its full growth in two or three months. This shoot may be of the thickness of a piece of straw and from 6 inches to 2 feet high. Next rains it puts out one or more shoots slightly larger both in height and diameter than the original shoot. Then, according to the species, it either again puts out more small shoots, generally speaking larger than those of the previous year, or puts out one or two distinct stems (culms) of several feet in height, and of an inch or more in girth. After that, given a normal monsoon, each year's culms tend to increase in height and diameter until the plant reaches maturity, by which time the culms put out each year have reached their maximum size. On the flowering of the bamboo the whole clump dies and new plants spring up from the seed. (A few species are an exception to this rule such as *Bambusa lineata* and *Ochlandra stridula.*)

The various cycles at which the different species flower will be dealt with hereafter. When the mature clump puts out a new culm during the rainy season, the diameter of the culm rising from the ground is the same as that when it reaches its full length; in other words, it does not increase in girth while putting on its height-growth. It grows extremely quickly attaining its full height in a few weeks or at the most during the monsoon months.

Size of culms.—The number of culms put out by a clump varies according to its age and size and also with the species. A large vigorous clump of Kyathaung (*Bambusa polymorpha*) may put out as many as 20 new culms a year. The amount of storage material which the rhizomes or root-stock of the clump has accumulated during the period of rest is fixed so that if the clump puts out an abnormal number of culms in any one year their size will be affected and they will be little, if any, longer or of greater girth than the previous year's shoots. On the other hand, if relatively few shoots are put out and the reserve material for their growth is sufficient, the size of the new shoots may be larger than the stems of the previous year. Again, if a number of bamboo clumps are inspected, there will be found here and there abortive shoots which have never reached maturity or attained their full height. Such abnormal growth is due to the root-stock having failed to supply sufficient nourishment to the culm to enable it to attain maturity.

Number of culms put out by a clump.—The actual number of culms put out by each clump, as was stated before, varies according to the size and age of the clump. In order to fix the rotation on which it is best to cut bamboos, it is necessary to know how many stems are put out, on the average, each year, by different species. With this object in view differentiation was made between under-one-year old and over-one-year old culms, when counting bamboo sample plots on the West Coast and in Burma.

By a culm under-one-year old is understood a culm which has not gone through two monsoons. By an over-one-year old culm is understood a stem which came into existence during one monsoon and which has passed through a second rainy season.

The prevailing species of bamboo on the West Coast is *Bambusa arundinacea*. Of this species the number of new stems counted was 2,675 against 9,160 old ones or in the proportion of one new stem to every 3·42 old ones.

In the Pegu Yomas, in Lower Burma, two of the commonest species are Tinwa (*Cephalostachyum pergracile*) and Kyathaung (*Bambusa polymorpha*). Of the former, 4,047 new culms were counted in the sample plots against 11,870 old ones or in the proportion of one new culm to every 2·93 old ones. Of the latter, 4,881 new culms were counted against 20,633 old ones, or in proportion of one new culm to 4·22 old ones.

The question of the proportion of new to old culms will again be dealt with when the rotation, on which the felling cycle for bamboos should be fixed, comes under discussion.

It has been explained above that the number of new culms put out per clump depends on the size and strength of the clump during any given period of its life. In order to collect definite data on this point Mr. Buchanan, a Forest Officer in Upper Burma, carried out careful countings in two successive years in sample plots chosen by him in average bamboo forest. The following table gives the results of his experiments :—

Experiments carried out in bamboo forests by Mr. E. M. Buchanan, Extra-Deputy Conservator of Forests, Myitkyina Division, Burma, in order to ascertain the number of new culms put out annually by various species of bamboos, and the yield of dry internodes per acre.

Date of counting.	Sample plot.	Species.	Number of clumps counted.	Number of culms counted.		Number of experimental culms cut.	Average length and mid-girth.		Total weight, in lbs.		Weight of nodes, in lbs.	Weight of dry internodes, in lbs.	Yield of dry internodes per acre, in lbs.	Remarks.
				Old.	New.		length.	girth.	green.	dry.				
Countings on 2nd November 1910.	A. One acre .	*Dendrocalamus Hamiltonii* (Wabom-yetsangye).	107	1,162	174	50	39′-6″	7·2″	1,402·5	..	..	..	..	Mr. Buchanan states that neither the clumps of *Cephalostachyum pergracile* nor *Bambusa pallida* are as yet mature, while those of *Dendrocalamus Hamiltonii* he classes as middle-aged.
	B. One acre .	*Cephalostachyum pergracile* (Tinwa) .	448	2,993	338	50	42′-1″	6·6″	1,383·5	640·02	66·97	573·05	..	
	C. One acre .	*Ditto ditto* . .	387	2,938	535	50	39′-9″	6·5″	1,202·5	663·57	64·97	598·60	..	
		Average per acre of sample plots B and C.	417·5	2,965·5	436·5	50	40′-11″	6·5″	1,293·0	651·79	65·97	585·82	39,871 or 18·77 tons	
	D. One acre .	*Bambusa pallida* (Samidu-Wa) . .	1,112	5,411	282	100	39′-11″	6·2″	2,036·7	1,055·4	113·7	..	..	
Countings on 23rd September 1911.	A. One acre .	*Dendrocalamus Hamiltonii* . .	..	..	*47	..	..	..	..	..	..	..	..	*These are the number of new culms put out during the rains of 1911.
	B. One acre .	*Cephalostachyum pergracile* . . .	..	..	*442	..	..	..	..	..	..	..	..	
	C.	*Ditto ditto* . . .	..	..	*384	..	..	..	..	..	..	..	..	
				Average .	413	..	..	..	..	..	..	..	..	
	D. One acre .	*Bambusa pallida*	..	..	*293	..	..	..	..	..	..	..	..	

NOTE.—He proposes to carry out further experiments by thinning the clumps, in order to ascertain the effect of cutting out mature culms on the growth of new shoots. The results of these experiments, when completed can be communicated, to any interested persons who care to make enquiries of the Forest Economist at Dehra Dun.

We are here chiefly concerned with the second species given in the above table, namely, *Cephalostachyum pergracile*, or Tinwa bamboos. The countings made in 1910 showed the two sample plots to contain an average of 417 clumps per acre, containing 2,965 old and 435 new culms, or a total of 8·1 culms per clump. It was found that 413 new shoots were put out by these clumps during the rains of 1911, that is 8·1 old culms were capable of producing, as nearly as possible, one new culm in one year. In Lower Burma countings made by the writer of the report (see Appendix I) gave one new culm to every 2·93 old ones, or roughly one new to every three old culms. The difference between the two results obtained is very marked, but nevertheless agrees in every respect with the mode of growth of bamboos. In the second paragraph of this section it has been explained how the culms and clumps as a whole increase in size, namely, that both the size of the stem produced and the number of culms put out in any given year depend on the power of the root-stock to store up nourishment against the period during which it has to produce new shoots.

Now the Tinwa bamboo clumps counted in Myitkyina Division by Mr. Buchanan were stated by him to be immature, while those counted in Lower Burma were somewhat over middle age, in other words, the root-stocks of the Myitkyina bamboos had not attained the same power of accumulating nourishment as had those in the areas inspected in Lower Burma and hence the difference in their relative power of producing new shoots every year.

In the foregoing paragraph, nothing has been said about the variation in climate in the two localities though, both areas, in which the countings were made, are typical bamboo areas for Upper and Lower Burma respectively. Without doubt the local conditions affect the growth of bamboos, so that the warm, damp, moist climate in Lower Burma no doubt partly accounts for the more favourable growth of *Cephalostachyum pergracile* in that locality.

4. Effect of cutting bamboos on the growth of the clump.

Effect of cutting stems on the growth of the clump.—The general impression arrived at after inspecting many areas in which fellings of bamboos have been carried on for many years, is that, in cases where a clump has been heavily cut over, the number of new stems put out is reduced according to the intensity of cutting, but that ultimately the

clump recovers, if given even only a short period of rest. And this is as might be expected, for the amount of nourishment which a clump can accumulate is governed by the leaf-area, so that when the leaf-area is reduced by felling a certain number of culms, the number of new shoots put out in the next season is correspondingly reduced. Another factor, however, comes into play when the vitality of a plant is reduced by cutting or pruning and that is that the plant struggles to regain its former normal state, so that with bamboos, which have enormous vitality, the deficiency is made up in a surprisingly short period of time.

Experiments on the cutting back of bamboos.—As a proof of the above assertion, there are to hand the records of experiments made some years ago in Burma, in connection with the extermination of bamboos to favour the growth of seedling teak.

The following is an extract from a letter on this subject from Mr. Muriel, Conservator of Forests, Pegu Circle, to the Chief Conservator of Forests, Burma :—

> "Experiments were made in the Tharrawaddy Division (new Zigôn and Tharrawaddy) from 1892 to 1897 to see if the cutting of the shoots of the year would cause the bamboo clumps to die * * *. An area of about 90 acres in the Kon Bilin Reserve of almost pure Kyathaung (*Bambusa polymorpha*) was operated over * * * An area of about 12 acres in the Bawbin Reserve of Kyathaung and Tinwa bamboo (*Cephalostachyum pergracile*) was similarly operated over * * * The experiment, as in the case of the Kon Bilin, being merely to determine the effect on the vitality of the bamboo clumps by cutting the annual shoots and *in both cases the experiment failed to have any appreciable effect on the vitality of the clumps.*"

In the above instance only the new shoots appear to have been cut. There is, however, to hand another experiment which was carried out in the Yaw Division, a copy of the report on which was sent by Mr. E. S. Carr, Conservator of Forests, to the Chief Conservator of Forests of Burma. The following extract is from the report by the Divisional Forest Officer, Yaw Division :—

> This work was incidental with the clearing of other undergrowth carried out in connection with an experiment, the

object of which was to determine the effect of cutting back bamboos over teak saplings (experimental plots Nos. 1 and 2, Lema, Gangaw Sub-division)."

"The following is taken from the Experimental Journal:—

March 1904. Forest Growth.

In both plots Myinwa (*Dendrocalamus strictus*) is plentiful occurring in clumps of about 20 to 40 stems and averaging 40 ft. in height.

Cultural operations.—Plot 1, practically cleared of bamboos and undergrowth."

"1904-05. Again completely cleared of undergrowth and bamboos."

"1905-06. *Inspection Notes.*—The effect of cutting back the bamboos has been to weaken it and out of each clump about one stem of 15 ft. high has been sent up.

"1906-07. *Inspection Notes.*—It is of interest that fresh culms arising from the old cut back clumps numbered from 4 to 5 stems per clump, as the result of two years' growth. They have been cut back again to facilitate getting about the area."

"1907-08. *Inspection Notes.*—It might be observed that most of this year's bamboo shoots in Plot 1, from the old stumps, have flowered."

"1908-09. *Inspection Notes.*—In Plot 1 the bamboo clumps cut down again have sent up one or two culms."

From the above records it is clear that even under the most drastic treatment, when the clumps are completely felled, several times in succession the old stock gradually recovers, and that it is practically impossible to completely destroy the plant in this way. It must, however, be recognised that the plant is weakened by over-felling and that to insure a sustained yield it must be given a period of rest between each successive felling.

5. Flowering of bamboos.

Flowering of bamboos.—The flowering of bamboos is a very complicated subject. The late Sir Dietrich Brandis, one of the greatest

experts on bamboos, divides them up into three classes when dealing with this question. The first group seeds yearly or nearly so and dies after flowering. With the species included in this group we are not concerned. The second he describes as flowering gregariously and periodically, all culms of one clump and all clumps in one district flowering simultaneously. He adds, however, that in different districts they flower at different times. In this case the culms die after ripening their seed, and usually the under-ground rhizomes also die. To this class belong *Bambusa polymorpha* (Kyathaung) and *Bambusa arundinacea*, two species with which we are closely concerned in the paper-pulp business. The third group contains irregularly flowering species, amongst which come *Cephalostachyum pergracile* (Tinwa).

Definite data as to the intervals at which the different species of bamboos flower are not yet available. Brandis states that *Bambusa polymorpha* flowers at long intervals, he records it as flowering in different localities in Burma in 1854, 1859, 1860, 1862 and 1871. Since then no general flowering has been recorded. *Bambusa arundinacea* of the West Coast and Peninsula is said to flower every 30 to 32 years, while *Cephalostachyum pergracile* (Tinwa) belongs to the third class, and is said by Brandis to flower frequently, at times gregariously over large areas. While on inspection in the Toungoo Division, an area of Tinwa which flowered in 1904 was seen; many of the old dead culms were standing over a dense crop of young plants, six years after the flowering had taken place, and these old culms, though dry, appeared still suitable for pulping. *Melocanna bambusoides*, the last species with which we are concerned, flowers at long intervals. Brandis states that in Arakan it flowers every 30 to 35 years. The writer inspected certain areas which had flowered in various places in Arakan and he arrived at the conclusion that the bamboos flowered in large patches of several square miles on one hill-side, but found no instance of wholesale flowering all over one district or large catchment area.*

The question of the flowering of the bamboo and its subsequent drying is a factor that has to be seriously considered as affecting the sustained yield. There are, however, certain factors which make it possible to rely on a continued supply of raw material from the bamboo areas. The first is that generally more than one species occurs in every

*NOTE.—It is understood that *B. arundinacea* has flowered heavily in certain localities of Kanara during the rains of 1911. Since the above was written the writer has noted nearly universal flowering of *M. bambusoides* in the Cachar Division of Assam.

forest and that the chances of them all flowering at the same time are very remote; secondly, that though the flowering may take place in one catchment area, or even over a whole district, at one time, the areas covered by bamboos are so vast that raw material will always be available from other localities, though the cost of extraction may be slightly increased for a time; and again dry culms do not disappear at once, so that the period during which the new crop is coming into existence may be partly tided over by extracting the dry culms to supply the mill; and lastly both *Bambusa polymorpha*, *Bambusa arundinacea** and *Melocanna bambusoides** only flower at long intervals.

6. Felling of bamboos.

Rotation on which to cut bamboos.—Bamboos have only been cut on a fixed rotation in places where the demand exceeds the supply. This is the case in the Lansdowne Division of the United Provinces, where the rotation is fixed at two and three years according to locality. We know nothing about the rotation for cutting *Bambusa polymorpha*, *Bambusa arundinacea*, *Cephalostachyum pergracile* and *Melocanna bambusoides* with which four species we are chiefly concerned.

On page 18 under the heading "Number of culms put out each year" it was stated that the proportion of new culms to old was as follows:—

	New.		Old.
Bambusa arundinacea	1	to	3·42
Bambusa polymorpha	1	to	4·22
Cephalostachyum pergracile	1	to	2·93
Average	1	to	3·52

The ratio therefore stands at 1 to 3·52, or say, as 1 to 4. It, therefore, requires four old culms to produce one new culm. Based on these figures, it takes four years to replace the old culms, leaving arithmetical progression out of the question. Now as the outturn from the areas dealt with in this report are capable of yielding annually a far greater quantity of material than any mill is likely to require for the present, the proposed rotation on which the sustained yield is based is put for

*NOTE.—It is understood that *B. arundinacea* has flowered heavily in certain localities of Kanara during the rains of 1911. Since the above was written the writer has noted nearly universal flowering of *M. bambusoides* in the Cachar Division of Assam.

safety's sake at five years. From experience it may be possible to reduce the rotation of felling for certain species of bamboos.

The rotation on which *Melocanna bambusoides* can be cut is put at 7 years, this figure having been arrived at by inspecting even-aged crops of this species in the Arakan Division.

Method of executing the cutting.—As has been shown above, it is not advisable to cut all the stems in one clump, as though by so doing the clump would probably not die, such drastic treatment would weaken it considerably. It is therefore proposed that 25 per cent. of the culms should be left per clump, of which at least half be young ones, to divide the area roughly into five blocks, and to carry out the cuttings in one block each year. Such an arrangement would not be possible were the total possible yield not far in excess of what is actually required. On the other hand, by such an arrangement the supply would certainly be maintained for ever.

After the cuttings have been carried out for one rotation and the effect of doing so ascertained, it might quite likely be found possible to modify the rules in the light of further experience. In any case, the Local Governments will, from the first, frame their own rules as regard the cuttings, which will be settled when a firm or company comes forward to apply for a concession, so that the above observations are only an outline of the possible solution to the problem.

Cutting stems of different ages.—As regards cutting stems of different ages, in practice it will be difficult to do more than differentiate between those under and over one year old.

In the past while carrying out laboratory tests, the experts have made fine distinctions between culms of 1, 2, 3, 4 years and over. As above stated, this is of no value in practice, as it is certain that while cutting bamboos on a large scale it will not be possible to make the coolies differentiate further than between under-and over-one-year old culms.

The effect on the growth of a clump by cutting under-one-year old culms is still a disputed point. It is generally recognised that they should be left standing. However, in the light of the experiments carried out in the Tharrawaddy and Yaw Divisions, and after inspecting a very large number of clumps over which fellings have taken place, it appears that the harm done to the clump is not so great as it is generally supposed to be. It is therefore thought that, provided about 50 per cent. of the new shoots are spared and that the cuttings are carried out

on a five-year rotation, there will be no harm done by cutting the other 50 per cent. of the new shoots.

7. Size and weight of bamboos.

Size and weight of culms of various species.—An important point is the size and weight of the culms of various species, as on these factors depends the facility and cost of their removal from the forest to the mill. Throughout this report the calculations of weights of dry bamboos and the yield per acre are based on the assumption that the nodes cannot be treated. This has been done for safety's sake, as by so doing the possible yield in tons from a given area is reduced and the cost increased. If, however, as demonstrated by the recent tests carried out on commercial lines at the Titaghur Paper Mills with chopped bamboos and by Raitt in his laboratory experiments with crushed bamboo, the nodes can be reduced to pulp (about which there is now no doubt), the estimates of yield per acre in this report may be raised 15 per cent. for *B. arundinacea*, 10 per cent. for *B. polymorpha* and *C. pergracile*, and 7 per cent. for *M. bambusoides*, while the cost of extraction may be reduced in proportion.

The following is the average size and weight of culms of the four species here dealt with :—

Species.	No. of culms on which the figures are based.	Average weight of one green culm, in lbs.	Average weight of one dry culm, in lbs.	Weight of dry internodes yielded by one culm, in lbs.	Average length, in feet.	Average mid-girth, in inches.
Bambusa arundinacea	1,084	62·0	42·0	35·7	44·3	8·9
Bambusa polymorpha	400	35·96	Not known, as the nodes were cut out green.	20·05	43·6	9·3
Cephalostachyum pergracile.	400	15·08	Do.	9·82	33·05	6·05
Melocanna bambusoides	10,575	2·45	1·55	...	22·0	3·8

NOTE I.—The length of the culms was taken after cutting off the thin top where it was about one inch in girth, the figures being the average of culms cut in six districts of Bombay and Madras, four in Burma and one in Arakan.

NOTE II.—For full details on which the above figures are based, see Appendices I to VI.

NOTE III.—These figures are averages based on all countings made in various localities.

8. Cost of extraction.

Cost of extraction.—The cost of extraction must vary according to locality and species. In part IV of this report figures are worked out for each area dealt with; thus no general figure can be given. It will here be sufficient to summarise the various rates of cost in a table by showing the rates for each locality.

Cost of extracting bamboos in various localities in India and Burma.

Locality.	Species of bamboo.	Method of extraction.	Cost of extraction to mill, per 100 stems.	Cost of landing a ton of dry internodes at a mill.
BURMA.			*Rs. a. p.*	*Rs. a. p.*
(1) The Thonzé Reserve of the Tharrawaddy Division.	*Bambusa polymorpha.*	Floating	4 0 0	5 12 9
	Cephalostachyum pergracile	Ditto	2 8 0	7 6 0
(2) The Hlaing Yoma and Okkan Reserves of the Rangoon Division.	*Bambusa polymorpha.*	Ditto	4 0 0	5 12 9
		By road and rail.	9 8 0	10 14 0
	Cephalostachyum pergracile.	Ditto	3 0 0	8 13 7
			5 8 0	10 5 3
(3) Pyinmana Division	*Bambusa polymorpha.*	Floating	7 8 0	6 8 5
	Cephalostachyum pergracile.	Ditto	6 0 0	11 2 6
(4) The Bondaung, Kabaung, East Swa, and Saing Yané Reserves of the Toungoo Division.	*Bambusa polymorpha.*	Ditto	6 8 0	5 10 6
	Cephalostachyum pergracile.	Ditto	5 0 0	9 4 9
(5) The Seik Catchment area of the Arakan Division.	*Melocannā bambusoides.*	Ditto	1 0 0	14 11 0

Cost of extracting bamboos in various localities in India and Burma—(concld.)

Locality.	Species of bamboo.	Method of extraction.	Cost of extraction to mill, per 100 stems.	Cost of landing a ton of dry internodes at a mill.
			Rs. a. p.	*Rs. a. p.*
(6) The Kaladan and Lemru Catchment areas in Arakan.	*Melocanna bambusoides.*	Floating	1 8 0	21 12 0
BOMBAY.				
(1) The Gangavalli Catchment area in the West and East Kanara Forest Divisions.	*Bambusa arundinacea*	Ditto	11 0 0	9 14 5
		By carting	15 12 0	13 8 0
(2) The Kala Nadi Catchment area in the West and North Kanara Forest Divisions.	Ditto	Floating	10 0 0	9 0 0
(3) The Mungod Forests, of the East Kanara Forest Divisions.	Ditto	Carting to Bomanhalli;	8 7 0	8 6 0
		to Hubli.	16 6 9	13 1 0
MADRAS.				
(1) The Uppinangadi and Puttur bamboo areas in South Kanara Division.	*Bambusa arundinacea*	Carting and floating from Uppinangadi;	16 6 0	7 10 6
		ditto from Puttur.	23 12 0	11 13 0
(2) The Kanoth forest of the North Malabar Division.	Ditto	Carting	23 0 0	9 10 6
(3) The Nilambur and Amarampalam forests of the South Malabar Division.	Ditto	Floating: from Nilambur;	10 0 0	3 11 2
		ditto from Amarampalam.	15 0 0	5 8 10

NOTE.—In the event of it being found possible to pulp both nodes and internodes of any of the above species, the cost of landing one ton of dry internodes, as given in the last column, would be reduced from anything between 7 per cent. and 15 per cent. according to species.

The figures in the above table show variations from between Rs. 3 to Rs. 12 and in the case of the Kaladan and Lemru catchment areas Rs. 22 in the cost of extraction of one ton of dry internodes, and this is as might be expected, considering the varying conditions met with in the various provinces. The average is about Rs. 9 per ton for dry internodes and this figure is well within the economic limit of working, which is about Rs. 15 per ton.

A point which requires explanation is the relative cost of exploiting 100 bamboos as compared with the cost of landing one ton of dry internodes at the mill. Take, for instance, the Kanoth forests in Madras. It costs Rs. 23 to land 100 bamboos at the mill, while it only costs Rs. 9-10-6 to land a ton of dry internodes from the forest to that place. The reason for this is the enormous size to which the bamboos grow in that locality and therefore relatively few bamboos are required to make a ton of the raw material. The case is exactly the reverse in the Thonzé reserve of the Tharrawaddy Division, where 100 *Cephalostachyum pergracile* cost Rs. 2-8-0 only, but on account of their lightness it costs Rs. 7-6-0 to land a ton of dry internodes at the mill.

It is here of interest to note the figures of cost arrived at by Sindall in his report. In paragraph 31, page 13, of the report he writes: "Cost of bamboos for the manufacture of pulp, with bamboo costing Rs. 9-8-0 per ton, the value of the raw materials required for a ton of unbleached pulp works out at a reasonable figure."

From the above table of figures, which have been based on careful weighings of many stems, and on enquiries into the local conditions, the figure arrived at is generally lower than that quoted by Sindall; nevertheless, they correspond sufficiently closely to corrroborate that gentleman's estimates.

9. Outturn.

The outturn from any given locality must necessarily depend on the size of the area from which bamboos can be exploited and the size and density of the crop.

Valuation surveys in bamboo areas.—One of the most arduous portions of this enquiry has consisted in taking a very large number of sample plots and linear valuation surveys in the various areas which were inspected. In making these valuation surveys, after the sample plot had been laid out on the ground, every clump was counted within the area and every stem counted in each clump. In many cases the number of

stems was counted twice over so as to prevent any mistake being made. Further, while counting the number of stems in a clump, separate records were kept of the number of new and old culms. Another point kept in view was to always pick out areas where the growth of the bamboo was normal or slightly under normal. The results of these countings are given in detail in Appendices I to V.

Possible outturn from various localities.—These enumerations were made together with the weighings of green and dry culms, in order to ascertain the average yield per acre of dry internodes, so as to arrive at an estimate of the possible annual outturn of raw material in any given area. In the following table is given a résumé of the possible outturn for the various localities, which are described in detail in Part IV of this report:—

Locality.	Area from which bamboos can be exploited, in acres.	Species.	Approximate yield per acre, in tons.	Approximate annual sustained yield, working on a 5-year rotation, in tons.
BURMA.				
(1) The Thonzé Reserve of the Tharrawaddy Division.	40,037	*Bambusa polymorpha* and *Cephalostachyum pergracile.*	7·8	62,417
(2) The Hlaing Yoma and Okkan Reserves of the Rangoon Division.	86,700	Ditto	7·8	135,305
(3) Pyinmana Division.	271,372	Ditto	17·6	955,029
(4) The Kabaung, Bondaung, East Swa and Saing Yané Reserves of the Toungoo Division.	74,570	Ditto	17·6	261,842
(5) The Seik Catchment area of the Arakan Division.	57,600	*Melocanna bambusoides.*	7·1	58,423*

*NOTE I.—Calculated on a 7-year rotation against 5 years for the other areas.

Locality.	Area from which bamboos can be exploited, in acres.	Species.	Approximate yield per acre, in tons.	Approximate annual sustained yield, working on a 5-year rotation, in tons.
BOMBAY.				
(1) The Gangavalli Catchment area in the West and East Kanara Forest Divisions.	1st class area 38,643 2nd class area 30,080 68,723	*Bambusa arundinacea.*	1st class area 5·3 2nd class area 0·88	40,321
(2) The Kala Nadi Catchment area in the West and North Kanara Forest Divisions.	Valley forests 20,374 Gund forests 7,000 27,374	Ditto	Valley forests, 1st class, 5·3 2nd class 0·88 Gund forests 12·9	32,107
(3) The Mungod forests of the East Kanara Forest Divisions.	113,000	Ditto	2·2	55,028
MADRAS.				
(1) The Uppinangadi and Puttur forest of the South Kanara Division.	35,798	Ditto	2·9	17,051
(2) The Kanoth bamboo area of the North Malabar Division.	3,000	Ditto	13·2	7,980
(3) The Nilambur and Amarampalam bamboo areas of the South Malabar Division.	9,280	Ditto	10·9	17,676

PART III.

THE COST OF MANUFACTURING BAMBOO PAPER-PULP.

1. General remarks.

Points which required to be cleared up.—Up to the present-day no firm has put up a mill in British India in which bamboos are utilized for manufacturing paper-pulp. It has been known, however, for many years that bamboos yield an excellent pulp, a point which has been repeatedly demonstrated by various experts in the laboratory. It is thought that the reasons why no steps have been taken up to the present to utilize bamboos for paper-making on a commercial scale, are that (*i*) persons interested in this subject entertain doubts as to the possibility of obtaining a continuous supply of raw material, at a reasonable price, (*ii*) that, without definite information as to a suitable locality from which to exploit bamboos they are not prepared to take up the subject seriously, (*iii*) that they cannot accept the figures of cost of manufacture based on data obtained in the laboratory only.

In Part IV is given detailed information, for stated localities, of the possible annual outturn and cost of extraction of bamboos which, it is hoped, will definitely clear up these points; in this Part of the report it is proposed to deal with the last point, *i.e.*, cost of manufacture of bamboo-pulp.

Arrangements made for testing bamboos on a commercial scale.—In order to obtain, not an estimated but an actual figure of cost of manufacture, Messrs. F. W. Heilgers, Agents to the Titaghur Paper Mills, who were interested in this subject, addressed the Forest Research Institute in 1910, with a view to obtaining a large quantity of bamboos with which to carry out experiments on a commercial scale. The question of manufacturing pulp from bamboos being under enquiry by the Forest Economist at the time, an agreement was made with the firm to supply them with 20 tons of each of four different species of bamboo, on the understanding that the firm, in return, should give a report on the results obtained by them from their experiments. The results obtained by boiling the 80 tons of bamboos supplied to the firm will be dealt with hereafter.

2. Various processes by which the raw material may be converted into pulp.

Various processes for treating raw material.—There are four methods by which the raw material may be reduced to pulp, namely, by the sulphite, sulphate, and caustic soda processes and also by mechanical treatment. In connection with bamboo, the first process has been tried but bamboo sulphite pulp is extremely difficult to bleach, which renders the process unworkable on a commercial scale. The preparation of mechanical bamboo-pulp, so far as is known, has never been attempted and it is highly improbable that it could ever be prepared in this way. We are therefore only concerned with the sulphate and caustic soda processes. The former has been tried on a laboratory scale by Raitt, and he has obtained slightly better results by this process than those obtained with caustic soda. The results of his work are fully described in his report published in the Indian Forest Records, Volume III, Part III, entitled—"Report on the Investigation of Bamboo as material for Production of Paper-pulp." Whether the results obtained by the sulphate process in a mill will be equal to those obtained with caustic soda and whether the resultant half stuff will prove to be of equal quality, remains to be proved.

3. Species of bamboos for paper-making.

Species of bamboos.—The question of the species of bamboo useful for paper-making has been discussed elsewhere. It is not only a question of the suitability of any given species for the manufacture of pulp but also largely a consideration of the available supply in large quantities, etc., at cheap rates and from suitable localities. The four species dealt with in this report are :—

(1) *Bambusa polymorpha* (Kyathaung).
(2) *Cephalostachyum pergracile* (Tinwa).
(3) *Bambusa arundinacea* (Daugi).
(4) *Melocanna bambusoides* (Muli).

It is with these four species of bamboos that tests have been carried out on a commercial scale.

4. Preparation of the bamboo before treatment.

Nodes and Internodes.—A difficult point to settle was the vexed question of how to deal with the nodes or joints of the bamboo.

Experts up to recent times have been of opinion that the nodes and internodes could not be treated together, and at the time the writer first took up the enquiry, he was of the same opinion. Had it been known from the first that in the case of *B. polymorpha*, and *C. pergracile* both nodes and internodes could be treated together, much labour and time might have been saved. When inspecting the various bamboo areas and at the time of counting and weighing large quantities of bamboos to obtain figures of outturn per acre, the bamboos which were cut for this purpose were further cut into tubes and the nodes and internodes weighed separately. The results obtained are given in the Appendices, and throughout the report mention is made both of the nodes and internodes. To obtain the total weight of the bamboos it is only necessary to add the weight of nodes to that of the internodes, while in the case of B. *arundinacea* and possibly in that of *M. bambusoides* it will be necessary to cut out the nodes before treatment, so that the calculations, based on the internodes only, have been left as they are in the report.

Crushing versus *cutting bamboos before treatment.*—To overcome the difficulty of treating nodes and internodes together, Raitt, in his above-quoted report, advocates crushing the bamboos between rollers and in this way proposes to reduce the material to a tow-like substance. This method has its advantages and disadvantages. The liquor acts more readily on the crushed material resulting in more rapid liberation of the fibre; on the other hand, the material is rendered more bulky and the capacity of a digester is reduced by one-half.* The other method is to chop the material into narrow sections about 1″ long. The results obtained, by treating both nodes and internodes of B. *polymorpha* and *C. pergracile* bamboos, by cutting them into short sections and boiling them in large digesters, have proved most successful.

Washing bamboos before boiling.—Owing to the dust and dirt which is found in bamboos, especially those which have been stored for a considerable time, it has been found necessary to first pass the cut chips through a fanning machine and afterwards to wash them in running water.

Steaming.—Raitt, in his report, advocates treating the bamboos by steaming or boiling them in water before introducing the liquor.

* NOTE.—Since writing the above Raitt has been able to reduce the bulk of the raw material when crushed by a process of fractional distillation.

This is a most important point and one, which it is necessary to carry out, in order to reduce the amount of starch before introducing the liquor, otherwise the percentage of caustic soda required to reduce the raw material to pulp is considerably increased. A period of two hours boiling in water is thought to be sufficient, after which it may be run off and the caustic liquor introduced.

5. Results of boiling bamboos on a commercial scale.

B. polymorpha, "Kyathaung" *bamboos*.—In order to give a correct idea of the results obtained by boiling bamboos on a commercial scale it will be necessary to quote from the report received from the Titaghur Paper Mills. They write as follows :—

> "Our best results with *B. polymorpha* bamboos have been got with our special high pressure digester, which has been recently brought into use. So far we have been able to reduce our caustic to 18 per cent. and bleach quite up to our Government standard with 10 per cent. of 35 per cent. bleaching powder. Time under pressure was one hour at 110 lbs. and five hours at 80 lbs. per square inch. Our yield of pulp showed 46 per cent., caustic and bleach are calculated on the weight of air-dry bamboo. We are handicapped at present for want of a suitable cutter for the bamboo. This will be rectified at an early date, when we hope to still further modify our caustic and bleach."

C. pergracile "Tinwa" *bamboo*.—The following is their report on the trials made with this species :—

"Our trial boils with this species were made in our ordinary fibre digesters, at a pressure of 60 lbs. per square inch. The fibre was boiled with 23 per cent. of 77 per cent. caustic for ten hours. The pulp required 15 per cent. of 35 per cent. bleaching powder to bring it up to our standard of whiteness for Government printing paper. The yield in paper showed 40 per cent. caustic and bleach calculated on air-dry weight of raw material. Several boils were put through on similar lines with variations in time, caustic and pressure but the pulp obtained, under the above conditions, was probably the best of the boils."

They go on to state: "the *C. pergracile* or Tinwa sample lot was all used up in trials at the lower pressure of 60 lbs., but we have no doubt it will give equally good results with *B. polymorpha* under similar treatment."

B. arundinacea, "Daugi" *bamboos*.—Their report on this species runs as follows:—

"This species we boiled for twelve hours with 24 per cent. of caustic and it came out much under-digested. This bamboo is a failure so far as our experiments have gone, but this does not mean that the species is useless for paper-pulp, but that further investigation is necessary, in order to find out the proper method of treatment."

B. arundinacea is an extremely heavy species, with thick walls and heavy nodes, it is very probable that Raitt's method of crushing will have to be resorted to in order to treat this species, and possibly it may also be found necessary to cut out the nodes.

M. bambusoides, "Muli" *bamboos*.—The report on this species runs as follows:—

"We treated this species exactly as in the case of *B. polymorpha*, but the fibre was not fit to make white paper. It gave a good looking pulp, but it would not bleach with a reasonable quantity of bleaching powder. Also small black stringy fibres appeared throughout the pulp, which are most objectionable, as they cannot easily be taken out and would spoil white paper, even if the bleaching difficulty were got over."

It is evident that *Melocanna bambusoides* bamboo will require further testing, before it can be used for paper-pulp.* The question of producing a better colour by bleaching, within economic limits of working, may possibly be overcome by treating this species by the sulphate process. The appearance of dark stringy fibre in the pulp may very likely be due to the black fibre in the nodes, or in the sheath in which case it will be necessary to cut out the joints or get rid of any adherent portions of the sheath.†

6. Cost of manufacturing one ton of air-dried unbleached pulp.

The whole question of manufacturing bamboo-pulp at a profit, that is to say, a pulp capable of being converted into high class printing

* NOTE.—Further tests with this species of bamboo have been arranged for, the bamboos for testing being sent from Arakan.

† NOTE.—It has been ascertained, since writing the above, that the sheath is the cause of the black stringy fibres, and these can easily be cut off before treatment.

paper, depends on the cost of production. Taking the figures arrived at by boiling *Bambusa polymorpha* or Kyathaung bamboo on a commercial scale and the cost of the raw material as given in Part IV, we arrive at the following figures of cost for manufacturing unbleached bamboo-pulp in or near Calcutta.

Calculation based on a 46 per cent. yield on weight of air-dried material obtained by boiling with 18 per cent. caustic.

1. The amount of raw material required to make one ton of air-dried pulp is 2·17 tons. The cost of one ton of air-dried bamboo in Rangoon may, on an average, be said to be Rs. 10 (see Part IV), therefore the cost of 2·17 tons works out at Rs. 21-11-0. Freight from Rangoon to Calcutta Rs. 7 per ton or Rs. 15-3-0 for 2·17 tons. Total cost of raw material, to produce one ton of unbleached pulp in Calcutta, therefore, works out at Rs. 36-14-0.

2. It requires 18 per cent. of caustic soda to reduce 2·17 tons of raw material to one ton of pulp or a total of 7·8 cwts., say, 8 cwts. at Rs. 6 per cwt. of fresh and recovered caustic works out at Rs. 48.

3. Cost of coal, of which 1½ tons are required to produce one ton of pulp, at Rs. 9 per ton = Rs. 13-8-0.

4. Labour, superintendence, Rs. 10.

5. Fixed charges, depreciation, repairs, etc., Rs. 10.

Abstract.

	Rs.	A.	P.
Raw material	36	14	0
Chemicals	48	0	0
Coal	13	8	0
Labour	10	0	0
Fixed charges	10	0	0
TOTAL	118	6	0

Were the pulp to be manufactured in Rangoon, the cost of the raw material would be reduced by Rs. 15-3-0 while the cost of the coal would be increased by Rs. 6-8-0, so that the cost of unbleached pulp in Rangoon works out at Rs. 109-11-0.

Comparing the cost of other unbleached paper-pulp in Calcutta we obtain the following figures:—

Unbleached *Sabai* grass soda pulp, per ton	Unbleached *spruce* sulphite pulp, per ton	Unbleached *bamboo* soda pulp, per ton
Rs. A. P.	Rs. A. P.	Rs. A. P.
162 2 0	150 0 0* to 155 0 0	118 6 0

In calculating the cost of manufacturing bamboo-pulp, various estimates have been put up by experts, based on their laboratory experiments. Raitt, in his report, estimates Rs. 92-8-0 as the cost of preparing unbleached sulphate bamboo-pulp. These figures are for unbleached bamboo-pulp near Rangoon. His figures differ from the above figures in that his chemicals cost Rs. 29-14-0, as against Rs. 48-0-0 in the above estimate, otherwise they are more or less in agreement.† Sindall, on page 43 of his report entitled "Bamboo for paper-making," 1909, estimates the cost of manufacturing bamboo unbleached pulp at £5-10-0, a most optimistic figure.

In arriving at the figure of Rs. 118-6-0 for unbleached bamboo-pulp in Calcutta, it will be seen that all items have been somewhat liberally estimated, probably when extracting bamboos on a large scale it will be found possible to do so for less than Rs. 10 per ton, while the sum fixed for labour and fixed charges, Rs. 20 in all, is a higher figure than that generally adopted by experts.

In spite of the liberal estimate given, the total cost of producing unbleached *bamboo*-pulp works out at Rs. 32 per ton lower than that for imported unbleached *spruce*-sulphite and Rs. 24 per ton lower than the cost of producing unbleached *Sabai* grass-pulp.

* NOTE—This figure includes the manufaturer's profits, while the figures given for Bamboo and Sabai grass soda pulp do not include his profits.

† NOTE.—The reason for the difference in cost of chemicals is that the amount of recovery, as accepted in this report, is based on that obtained when working with grass, whereas Raitt maintains that greater recovery can be expected from Bamboo. His contention is no doubt correct, but until more reliable data are forthcoming on this point it is safer for the present to adopt the higher figure.

PART IV.

DETAILED REPORTS ON THE VARIOUS BAMBOO AREAS IN BURMA AND INDIA.

POSSIBLE SITES FOR BAMBOO PAPER-PULP MILLS IN BURMA.

BURMA AREA NO. I. (*See portion marked* **A** *on map.*)

The Thonzé Reserve of the Tharrawaddy Division.

(1) *Name and Situation.*

The forests with which this scheme is concerned are situated in the catchment area of the River Thonzé, which drains a portion of the western slopes of the Pegu Yoma in the Tharrawaddy Division. This river finds its source in the main ridge of the Yomas and follows a winding course south-westwards, through the lower hills of the range until it emerges into the plains at Wéywa. Thence it passes between deep banks to the village of Thonzé, where it cuts the railway, and eventually six miles lower down flows into the Myitmaka at Sanywé. (See map.)

This area, which has been chosen as a possible locality from which bamboos might be exploited to supply a pulp-mill, lies to the north of the Okkan Reserve of the Rangoon Division, which is dealt with hereafter, and is a continuation of those forests, though lying in a different catchment area. Again, to the north of this area, lies the Kadin Bilin reserve, drained by the Bilin River, and also a continuation of the same block of forest, which stretches northwards from the Okkan river along the western slopes of the Pegu Yoma for a distance of many hundreds of miles.

(2) *Description of the forests.*

The area is, for the most part, covered with dry deciduous teak, pyinkado and bamboo forests, with patches of evergreen in the moister localities, a large number of teak plantations near the western boundary and 8,000 acres of inferior forests, ceded to the Karens, in which to practise shifting cultivation. By far the greater portion of the area is fully stocked with bamboos of four or five different species, and only in

some of the plantations, evergreen and Karan areas, are they in any way scarce. These forests and those of the Okkan which are described hereafter, resemble each other, especially as regards the growth of bamboos.

(3) *Area of the forest covered with bamboos.*

The total area of the forests situated in the catchment area of the Thonzé River is 69,734 acres, which is made up as follows:—

1. Area from which bamboos can be exploited	40,037 acres.
2. Evergreen forest	8,000 ,,
3. Karen area in which shifting cultivation is practised . . .	8,200 ,,
4. Area containing bamboos but from which exploitation is difficult	13,497 ,,
TOTAL .	69,734 acres.

The area, therefore, with which we are concerned is 40,037 acres, from which bamboos can be exploited without difficulty. It may here be mentioned that, out of the 13,497 acres in which bamboos occur, but from which exploitation is difficult, 4,565 acres are situated above the waterfall on the Kodugwé tributary and 8,932 acres are situated on the steep slopes of the main ridge of the Yomas, whence extraction would be difficult and costly.

(4) *Species of bamboos and mode of growth.*

The prevailing species in these forests are *Cephalostachyum pergracile* (Tinwa) and *Bambusa polymorpha* (Kyathaung); *Dendrocalamus strictus* (Myin) is common on the ridges and *Teinostachyum Helferi* (Wathabut) along the streams and in the evergreens. From Appendix I it will be seen that the average length of 200 cut stems of Tinwa is 28 feet and mid-girth 5·7″, while an equal number of Kyathaung average 33 feet and 8·8″ mid-girth. An important point in the growth of bamboos is the number of new stems put out yearly as compared with the number of old stems in the clump. From Appendix I we find that the average number of Tinwa stems per clump is about 9 of which 23 per cent. are new and 77 per cent. old, or in round figures as 1 is to 3. In the case of Kyathaung the number of new stems is proportionally greater. The figures show roughly 11 stems per clump, of which 30 per cent. are new and 70 per cent. old, or as 1 is to $2\frac{1}{3}$.

(5) *Possible factory sites.*

There are two possible factory sites. One is where the Thonzé river cuts the railway at the village of Thonzé, two miles south of Tharrawaddy railway station (see map), the other is near Insein on the Hlaing or Myitmaka river. Were the latter site to be chosen, the Thonzé and Okkan bamboo areas could be worked together. The advantages of the latter site will be fully described under this head in the Okkan scheme. (See page 48, section 5.)

The first suggestion is to have a mill at or near the village of Thonzé, on the banks of the river. Such a place has distinct advantages. It is on the railway and also near a good perennial stream of water. It is 12 miles by river from the edge of the bamboo area at Wéywa and 20 miles from the centre of the forests. From Thonzé, to the junction of the river with the Myitmaka at Sangwé, is 6 miles and along this stretch of river small boats loaded with 2,500 to, 3,000 lbs. of rice ply without difficulty. From the junction of the rivers at Sangwé boats carrying 10—12,000 lbs. of rice go down to Rangoon. It might be thought advisable to place the factory at Sangwé, but this is not practicable, as the river overflows its banks in the monsoon, a circumstance which would practically stop all work during those months and possibly damage the mill.

(6) *Outturn.*

As will be done when calculating the outturn from the Okkan and Hlaing Yoma Reserves, the figures of yield for this reserve are based on the average outturn per acre of all the sample plots situated in the two bamboo areas, namely, those of the Thonzé and Okkan Reserves. This has been done in order to obtain a more reliable figure, as the forests of both divisions are of the same type as far as bamboos are concerned.

The area of the bamboo-yielding forests in the Thonzé Reserve has been shown as 40,037 acres. From Appendix I it will be seen that an acre yields 8,254 lbs. of dry internodes of *Cephalostachyum pergracile* (Tinwa) and 9,255 lbs. of dry internodes of *Bambusa polymorpha* (Kyathaung). Thus the gross yield of pulpable material works out at 312,288 tons, or, working on a 5-year rotation, the sustained yield of dry internodes comes to 62,417 tons per annum.

Were the Kadin Bilin catchment area, which lies directly north of the Thonzé Reserve and which is a continuation of the same block of forests, to be worked in addition, the outturn could be nearly doubled.

The export of bamboos from the Thonzé Reserve is already considerable. The bamboos are floated down the river, some are sold locally in Tharrawaddy, but the greater number are taken on down the Myitmaka to Rangoon. The outturn of all species of bamboos during the last five years was as follows:—

Year.	Number.
1905-06	629,100
1906-07	546,550
1907-08	497,000
1908-09	494,700
1909-10	503,500
Average	534,170

(7) *Lines of export.*

The bamboos are at present dragged to the main or by-streams, a distance of under a mile. They are then rafted down the main stream from 15th May to the end of November. After November and up to February, rafts can still be taken down, but they require to be pushed in places, thus rendering the cost of extraction higher. Floating is carried on down the by-streams from the commencement of the monsoon until October. The greatest distance over which floating is necessary, namely, from the foot of the main ridge of the Pegu Yoma at Kaingdagyi to Thonzé, is 32 miles. A waterfall exists on the Kodugwé, on one of the largest northern tributaries, at a distance of 7 miles from its junction with the main stream. Floating is, therefore, not possible above this point, and in estimating the area of bamboo forest, the compartments above the waterfall have been excluded from the calculation.

Once the bamboos are in the main stream no difficulties occur in floating them down to the village of Thonzé or on to Rangoon.

The question was once raised by a District Forest Officer whether by floating large quantities of bamboos down this river the floating of the teak logs, annually exported from these forests, would not be interrupted. Careful enquiry was made on this point and the present District Forest Officer and also some of his subordinates, who have been working for many years in this locality, apprehend no difficulties.

The present method by which bamboos are extracted, is to make rafts of three sections, each containing 300 Kyathaung or 600 Tinwa bamboos; these are floated down the upper reaches in charge of one man. As the stream widens out, the rafts are increased in size and on reaching the Myitmaka or Hlaing river, several sections are tied side by side and rafted down in lots of 6,000 to 7,000 to Rangoon.

(8) *Cost of cutting and extraction.*

The present rates for selected straight Tinwa bamboos, 20 feet in length, at Thonzé on the railway line, is Rs. 3 to Rs. 5 per 100 stems and for Kyathaung Rs. 6 per 100 and for fine selected stems Rs. 8 per 100. This includes royalty and contractor's profit. The figure of cost of extraction of bamboos on a large scale of both species, taking crooked and straight stems together, is put at Rs. 3 per 100 by the Divisional Forest Officer. This includes profits to the contractor but not royalty charges. Were the Rangoon supply to clash with that of a pulp-mill, it is possible that the price might go up 25 per cent. A safe figure on which to base the cost of extraction will, therefore, be Rs. 2-8 per 100 stems of Tinwa, and Rs. 4 per 100 stems of Kyathaung.

(9) *Cost of landing dry internodes per ton at the factory site.*

Supposing Thonzé to be selected as a mill site, the cost of landing dry internodes at the factory will be as follows :—

(*i*) *Cephalostachyum pergracile* (Tinwa).—The weight of dry internodes yielded by one Tinwa is 7·6 lbs. (See Appendix I), and it requires 295 stems to yield one ton of dry internodes. Therefore the cost of extracting 295 stems or, in other words, of landing one ton of dry internodes at Thonzé at Rs. 2-8 per 100 comes to Rs. 7-6-0 per ton.

(*ii*) *Bambusa polymorpha* (Kyathaung).—The weight of dry internodes yielded by one Kyathaung is 15·4 lbs. (see Appendix I), and it requires 145 stems to yield one ton of dry internodes. Therefore the cost of extracting 145 stems or, in other words, of landing one ton of dry internodes at Thonzé, at Rs. 4 per 100, comes to Rs. 5-12-9 per ton.

(10) *Labour.*

A certain amount of local labour is available. It is said that 12 villages situated on the Thonzé and lying between the forest and the Railway could supply 300 to 400 coolies from June to November, but that in December the number would be reduced, owing to the commencement of rice harvest. On the other hand, were a mill to be started in these parts, it is probable that a far larger number of coolies would be forthcoming, once it became known that regular labour was obtainable on piece-work.

Turning now to the amount of work a man can do, it is known from experience that a good labourer can extract about 5,000 Kyathaung stems between June and November, so that 400 men could work out 2,000,000 stems in that time. Taking one stem as yielding roughly 15 lbs. of dry Kyathaung internodes, 400 men would extract 30 million lbs. or about 13,400 tons in the six months. The above figures make no allowance for loss in transit, so that 12,000 tons would be a safer figure to quote, and this amount would not be sufficient to supply a large mill. Under the circumstances it would be necessary to import labour, either from the neighbouring districts or from India, as is done to harvest the rice crop.

There would be no difficulty in procuring contractors who would undertake to exploit the bamboos.

The official rate for labour is 8 annas a day, though probably 9 annas would have to be given. It is said that a good workman can earn Re. 1 per day during the harvest season.

(11) *Firewood.*

About 100,000 c.ft. stacked firewood is annually available from the Plains Forests. Supposing the fuel supply required for a mill to be greater than the above amount, a rough working-plan could be prepared for the Thèwa and Kauni Fuel Reserves, and the coupes so arranged that a sustained annual yield could be procured. To do this arrangement would have to be made in advance.

The price of fuel at Tharrawaddy is Rs. 2-6-0 per 100 c. ft. stacked and at Thonzé Rs. 2-12-10.

(12) *Chemicals.*

No lime is available in the vicinity of Thonzé, so that it would have to be procured from Rangoon, where the price is about 5 annas per cubic foot. Excellent lime is also available in large quantities from Moulmein. All the other chemicals necessary would have to be imported to Rangoon by sea, and taken up the Rangoon river to the factory site.

(13) *Miscellaneous facts.*

The proposed factory site is situated in the plains and is surrounded by cultivation, chiefly rice. It is not an unhealthy spot, is well situated on a fair river and close to the railway. It is just possible that a more satisfactory site could be found lower down the river, nearer Rangoon and somewhere above tidal level. The forests are not unhealthy, except after the monsoon, when fever is prevalent.

BURMA AREA NO. II. (*See portions marked* ***B*** *on map.*)

The Hlaing Yoma and Okkan Reserves of the Rangoon Division.

(1) *Name and Situation.*

These forests lie in the Rangoon Division and are known as the Okkan and Hlaing Yoma Reserves. They are situated on the western slopes of the southern extremity of the Pegu Yoma and therefore lie to the east of the Irrawaddy river. In this locality the Pegu Yoma forms a range of broken hills rising to 800 feet with considerably higher points along the main ridge. They are drained by numerous small streams which find their way into the larger feeders of the Hlaing, the most important of which is the Okkan river, which flows through the central and northern portion of the area. (See map.)

(2) *Description of the forests.*

To the east of Palôn Railway Station occur what are known as the Plains Forests, in which extensive teak plantations exist, and in which comparatively few bamboos occur. About 8 miles east of the railway commences the broken hilly ground of the Yomas covered with

moist-deciduous forests, containing teak and other species, with continuous bamboo forests up to the top of the western watershed, which constitutes the boundary of the Pegu Division. This type of heavy teak and bamboo forest with small modifications, occurs all over the hill ranges, passing northwards through the Okkan Reserves into the Tharrawaddy Division.

(3) *Area of forests covered with bamboos.*

The above-mentioned Plains Forests, which constitute the North and South Hlaing Reserves, have been eliminated from this scheme, as they contain relatively few bamboos. The areas taken into consideration are those which comprise the forests situated on the hilly ground in front of the main ridge of the Yomas and which go to make up the western watershed of the main range. For the sake of convenience, the area has been divided into two parts, according to the lines of export available, though both reserves form one continuous block of forest :—

Name of reserve.	Compartment Nos.	Area in acres.
Hlaing Yoma Reserve	9 and 13 to 28	26,701
Okkan Yoma Reserve	29 to 100	81,663
	TOTAL .	108,364

(4) *Species of bamboo and mode of growth.*

The prevailing species are *Cephalostachyum pergracile* (Tinwa) and *Bambusa polymorpha* (Kyathaung) which together make up about 80 per cent. of the bamboo growth. *Dendrocalamus strictus* (Myin) occurs on the ridges, and is often found growing on poor soil, but, for reasons stated elsewhere, this species has not been included in the scheme. Besides the above bamboos, a creeping species occurs, known as *Teinostachyum Helferi* (Wathabut) and a bamboo named *Dendrocalamus longispathus* (Waya).

The two first-named species, Tinwa and Kyathaung, are very abundant. The former is a comparatively small unarmed bamboo, with an average stem of 6″ to 7″ mid-girth and cutting into lengths of 25 to 30 feet. It yields a fairly strong stem, but not thick-walled, and is easily cut and extracted. The latter is a larger unarmed bamboo, with

a mid-girth of 8″ to 9″ and cutting into lengths of 30 to 40 feet. It is thin-walled, with small nodes from 18″ to 29″ apart and is by no means difficult to extract. Both the above-mentioned species are softer and lighter bamboos than the prevailing species of the West Coast (*Bambusa arundinacea*) and being unarmed are therefore more easy to fell and extract. (For average size and weight of these species see Appendix I.)

(5) *Possible factory site.*

There are two possible ways of dealing with this scheme. The first is to locate the pulp-mill on the Okkan river, near to the point where the river cuts the Rangoon-Prome Railway, that is, 2 or 3 miles north of Okkan Railway Station and 13 miles from the outer boundary of the Okkan Reserve. The alternative proposal is to have a mill below the junction of the Okkan and Hlaing, otherwise known as the Myitmaka river, or in the event of no suitable site being found there owing to danger from floods, further down the stream at or near Insein, which is 10 miles above Rangoon. If the first site were adopted the supply of raw material would be confined to the Okkan and Hlaing Yoma Reserves, which are themselves capable of supplying sufficient bamboos to work a large paper-pulp mill. On the other hand, were the mill placed at Insein on the Hlaing river, of which the Thonzé as well as the Okkan are tributaries, the former draining a bamboo area to the north of the latter river, and fully described above, it would be supplied from two separate bamboo areas, and at the same time would be sufficiently far down the river to allow of large boats coming up from Rangoon. The respective merits of these two sites can only be compared after the capacity of the mill has been definitely determined. In fixing the site it would be of the first importance to consider the advantage of having two areas from which supplies of raw material would be available; the question of having a greater area over which to recruit labour; and the proximity and connection by water with Rangoon, as against concentration of labour and the proportionate reduction in establishment were the bamboos procured from one reserve only. As regards the water supply, there is always a sufficient quantity flowing down the Okkan and Hlaing rivers to meet the requirements of a factory at either place. These remarks apply with equal force to the scheme for the Thonzé Reserve described above.

(6) *Outturn.*

A considerable number of bamboos are extracted annually from the Okkan Reserve, the figures for the last five years being as follows:—

Year.	No. of bamboos.
1905-06	548,600
1906-07	487,100
1907-08	660,000
1908-09	700,000
1909-10	610,000
AVERAGE	601,140

So as to obtain a more reliable figure of outturn, based on the enumerations and weighings carried out in the various bamboo sample plots, it has been decided to take the figures obtained not only from countings in the Hlaing Yoma and Okkan Reserves of the Rangoon Division, but also those obtained from the sample plots in the Thonzé Reserve of the Tharrawaddy Division. Though these three reserves lie in two different Divisions for administrative purposes, they form one continuous belt of forests in the Pegu Yoma, in which the species and mode of growth of the bamboos is for all purposes the same.

The combined bamboo area of the Hlaing Yoma and Okkan Reserves is 108,364 acres. Portions of these areas contain no bamboos, such as Taungya areas, roads, river beds, and scarps, while areas also exist from which the extraction of bamboos would be too difficult and costly, so that, for safety's sake, we may reduce it by 20 per cent. leaving 86,700 acres of productive bamboo forest to be dealt with. From Appendix I it will be seen that the forest can yield 8,254 lbs. of dry internodes of *Cephalostachyum pergracile* (Tinwa) and 9,255 lbs. of dry internodes of *Bambusa polymorpha* (Kyathaung) per acre, or a total of 17,509 lbs. or 7·81 tons per acre. Thus the gross yield of pulpable material works out at 676,527 tons or, working on a 5-year rotation, the sustained yield of dry internodes comes to 135,305 tons per annum.

(7) *Lines of export.*

In forming an estimate of the cost of extraction and the methods by which the bamboos could be exploited, the proposed factory site is taken to be on the Okkan river, somewhere near to the point where that river cuts the railway. (See red circle on map.) However, were the factory to be erected near Insein on the Hlaing, otherwise known as the Myitmaka river, the extra expense incurred in floating the bamboos another 30 miles or so down from the Okkan railway bridge would be relatively small.

The Okkan river, with its tributaries, of which the more important are the Yindaik, Kangya, Chaungyaung and Mingaung, completely taps the Okkan Reserve, while the main stream passes the proposed factory site at Okkan village. It is not a large river, being about 50 yards broad where it comes out of the reserved forest, and its bed is sandy, with few boulders to impede floating. It is the main stream by which bamboo rafts are brought down to the railway from the Okkan forests. These rafts, of which several were being taken down when the river was inspected, are constructed in the upper reaches of the river and floated down any time from the middle of June to the middle of January. In the smaller tributaries floating is not possible after October. After the bamboos have been dragged to the main or by-streams, a distance of one mile or less, they can be floated directly from the forest to the factory, the distance from the centre of the Reserve to that place being about 18 miles.

The work of extracting bamboos from the Hlaing Yoma Reserve is of a somewhat different nature. From Compartments 9 and 13 to 25 the bamboos can be dragged and carted to Thanachaung Railway Station (see map), an average distance of 8 miles, and from there they can be railed to the factory near Okkan station, a distance of about 15 miles, while Compartments 26 to 28 and 29 to 30 can be worked out by dragging for a mile or so and carting 7 miles to Palôn station, whence they can be taken by rail some 10 miles to the factory. The lines of export are therefore very suitable for the extraction of bamboos, for when the supply of raw material from the Okkan Reserve is no longer available, owing to insufficient water in the river for floating operations, *i.e.*, during six months in the year, it will be possible, owing to the fair weather roads being open to cart traffic during the dry season, to exploit bamboos from the Hlaing Yoma Reserve, thus ensuring a continuous supply of raw material throughout the year.

(8) *Cost of cutting and extraction.*

The cost of cutting 100 *Cephalostachyum pergracile* (Tinwa) bamboos, dragging them to a by-stream and floating them to the edge of the reserved forest, for instance to the village of Shawbon, comes to Rs. 2, and for *Bambusa polymorpha* (Kyathaung) Rs. 3 per 100. The cost of making them up into rafts and taking them down to the factory site will come to Re. 1 per 100, or a total cost of Rs. 3 per 100 for Tinwa and Rs. 4 per 100 for Kyathaung. The royalty on bamboos is annas 5 per 100, while Tinwa bamboos, 20 feet long, sell at present in the Okkan market for Rs. 4 to Rs. 6 per 100 and Kyathaung, Rs. 5 to Rs. 7 per 100, according to quality.

For the Hlaing Yoma Reserve the estimates are as follows: Cost of cutting and dragging to a cart-road, Rs. 2 per 100 for Tinwa and Rs.3 per 100 for Kyathaung. Carting costs 3 annas per mile, and the average distance of the forest from the Railway is 8 miles, or Re. 1-8 per cart. A cart can take 100 Tinwa or 33 Kyathaung, so that the total cost of landing Tinwa on the station works out to Rs. 3-8 and for Kyathaung Rs. 7-8, per 100. To these estimates must be added the cost of loading and railing the stuff some 15 miles to Okkan, say Rs. 2 per 100, which raises the total cost to Rs. 5-8 and Rs. 9-8 per 100, respectively.

(9) *Cost of landing dry internodes per ton at the factory site.*

The weight of dry internodes yielded by one average Tinwa bamboo is 7·6 lbs. and that by a Kyathaung 15·4 lbs. (see Appendix I), therefore it takes about 295 Tinwa or 145 Kyathaung to yield a ton of dry internodes. The cost of landing the bamboos from the Okkan Reserve at the proposed factory site is Rs. 3 and Rs. 4 per 100 respectively, so that the cost of landing dry internodes of Tinwa at the mill works out to Rs. 8-13-7 per ton and of Kyathaung at Rs. 5-12-9 per ton.

The cost of landing bamboos from the Hlaing Yoma Reserve is Rs. 3-8-0 and Rs. 7-8-0 per 100 respectively, so that the cost of landing dry internodes of Tinwa at the mill works out to Rs. 10-5-3 per ton and of Kyathaung at Rs. 10-14-0 per ton. Were the site of the mill fixed at Insein, 8 annas would have to be added to the cost per ton. In the event of the nodes being utilised, the average cost of Tinwa and Kyathaung together works out to Rs. 10 per ton in round figures, and this is the figure taken by Raitt for his estimates.

(10) *Labour.*

Local labour cannot be relied upon at all To begin with it is scarce and only obtainable in limited quantities after the rice crop has been reaped. A Burma cooly can earn 9 annas to Re. 1 per day according to the nature of the work on which he is employed. Cooly labour from India is obtainable at Rs. 12-0-0 per month, and is extensively employed and with advantage by the Forest Department for work such as clearing fire-lines. It will certainly be necessary to import coolies from India, for Burman labour cannot be relied upon in sufficient quantities to run a large pulp-mill.

Carts are procurable in small numbers only, so that here again importation will be necessary. It is not generally possible to hire elephants, and if it were contemplated to use them for dragging purposes they would have to be purchased.

(11) *Firewood.*

Firewood cannot be obtained easily, for though large quantities are forthcoming from the forests, the difficulty in exploiting it would be considerable. Were it to be floated down the streams, it would probably interfere either with the floating of the teak or with the bamboos, while carting would be too expensive. Coal will, therefore, be necessary, and its price would be but little higher than in Rangoon, especially were the site of the factory to be fixed not far up the river from Rangoon and at a place in direct connection with that port.

(12) *Chemicals.*

No lime is available in the vicinity of the Okkan Reserve, so that it will have to be procured from Rangoon, where the price is 5 annas per cubic foot. Excellent lime is procurable in large quantities from Moulmein. All other necessary chemicals will have to be imported to Rangoon by sea, and taken up the Rangoon river to the factory.

(13) *Miscellaneous facts.*

The proposed site for a mill at Okkan is surrounded on every side by open country, generally under rice cultivation. It is a fairly

healthy locality throughout the year and is well suited to Europeans. It has the advantage of being on a good floating stream and also on the railway, some 50 miles from Rangoon. It is possible that, were a mill to be erected on a large scale, a better site would be further down the river, a few miles above Insein and near Rangoon, but such a point can only be settled by the firm or company intending to start the business.

BURMA BAMBOO AREA NO. III. (*See portion marked* **C** *on map.*)

Pyinmana Division.

(1) *Name and Situation.*

The area from which bamboos can be extracted from the Pyinmana Division is a block of forests at the foot of, and on the eastern slopes of the Pegu Yomas, commencing some 10 to 15 miles east of the Rangoon-Mandalay Railway. The forests are of two types, the northern portion being in the dry zone and consisting of a poor quality Cutch forest, the central and southern portions being in the wet zone, and containing teak, pyinkado, and bamboos. It is with the latter type of forest that we are concerned. For the purpose of working out the timber from this area, it has been divided into nine blocks, of which four are drained by the Ngalaik and five by the Yonbin, both of these rivers finding their way into the Sittang, to the east and south-east of the town of Pyinmana.

(2) *Description of the forest.*

(*1*) *The Ngalaik drainage.*—The following blocks make up the catchment area of the Ngalaik:—

(*i*) The Taungyé Reserve is the most northern block, and is drained by a tributary of the Ngalaik, which bears the same name as that of the Reserve. The river in its upper reaches is a poor floating stream, so that the upper portions of the forest are excluded from this scheme, though bamboos cover nearly the whole area.

(*ii*) The Ngalaik Reserve lies inside the Taungnyé, with its north-west limits covering the crest of the Yomas, in which locality bamboos occur, but would be difficult to exploit.

(*iii*) The Kaing Reserve is a small area of forest, to the south-east of the Ngalaik Reserve and is drained by the Ngalaik itself.

(*iv*) The Pozaungdaung Reserve lies close to the Railway on hilly ground, but not on the main ridge of the Yomas; it is well stocked with bamboos, of which a certain number are extracted annually from its eastern edge by small contractors. The tributary of the Ngalaik, known as the Chaungmagyé, drains this area.

(2) *The Yonbin drainage.*

(*v*) The Yanaungmyin Reserve is a comparatively small area lying on undulating ground on the outside edge of the Yoma blocks, and is drained by a small river called the Thebyu, a tributary of the Yonbin.

(*vi*) The Plawé Reserve is the most northern block drained by the Yonbin. It lies up against the main ridge of the Yomas, consequently it is difficult to extract bamboos from its upper reaches. It is drained by the Palwé Chaung, a tributary of the Yonbin, and a good floating stream.

(*vii*) The Yonbin Reserve in the west lies on the main ridge of the Yomas, and is drained by the Chaungmangyi tributary, also a good floating stream.

(*viii*) The Mynbyin Reserve lies to the south of the Yonbin forests, and is tapped by the Yonbin Chaung, a good floating stream.

(*ix*) The last reserve is the Yeni, which contains fine pyinkado forests. It has been decided to omit this area from the scheme as the river by which it is drained is a poor floating stream.

(3) *Area.*

In calculating the area of forests of the various reserves over which bamboos occur, those lying along the main ridge of the Yomas have been excluded, as the difficulty in exploiting the bamboos from that locality would probably render the cost excessive.

Besides the above localities, certain of the areas contain a type of forest known as "Indaing" in which bamboos are non-existent, while others are covered with bamboos unsuitable for pulping. To arrive at the areas, over which *Bambusa polymorpha* (Kyathaung) and *Cephalostachyum pergracile* (Tinwa) occur, Mr. Leete, the Divisional Forest Officer, was consulted and also his Assistants, many of whom have many years' experience of these forests.

In this way the following figures have been arrived at :—

Name of Reserve.	Actual area of Reserved Forests, in acres.	Area covered by exploitable Kyathaung and Tinwa bamboos, in acres.
(*i*) Toungnyé Reserve	69,546	34,773
(*ii*) Ngalaik ,, ...	80,013	60,009
(*iii*) Kaing ,, ...	13,341	10,005
(*iv*) Pozaungdaung ,, . . .	51,557	12,889
(*v*) Yanaungmyin ,, ...	13,078	6,539
(*vi*) Palwe ,, ...	89,222	44,611
(*vii*) Yonbin ,, ...	78,034	39,017
(*viii*) Mynbyin	127,059	63,529
	521,850	271,372 acres or 424 sq. miles

(4) *Species of bamboos and mode of growth.*

The species of bamboos which predominate in these forests are *Bambusa polymorpha* (Kyathaung) and *Cephalostachyum pergracile* (Tinwa). Other species occur such as *Oxytenanthera albociliata* (Wanwé), *Dendrocalamus strictus* (Myin) on the drier ridges, and others, but only Kyathaung and Tinwa are taken into consideration for the purposes of this scheme.

The *Bambusa polymorpha* (Kyathaung) and *Cephalostachyum pergracile* (Tinwa) grow to a large size in these forests, especially the former. In order to ascertain the girth, length and weight of culms of these

species (see Appendix II), 200 Kyathaung and the same number of Tinwa were cut and measured. The former gave average measurements of 10·1″ mid-girth and 49 feet in length, the thin tops being cut off. In the same way 200 Tinwa were cut, giving an average mid-girth of 6·3″ and a length of 38 feet. The weight of these bamboos green and of the dry internodes is dealt with under the heading (6) Outturn.

(5) *Factory site.*

The obvious site for a factory is somewhere on the Sittang river, but no suitable place exists over its course through the Pyinmana Division as the Railway runs at some distance from the river. It will, therefore, be necessary to fix a site lower down in the Toungoo Division, and the place suggested by Sindall in his report on the possibility of pulp manufacture in Burma (1906) is at the village of Kywebwé, which lies on Railway some 18 miles below Toungoo (see map). On visiting this place it was found that the river was two miles distant from Kywebwé and that it would be better to place the mill at Myozo, on the Sittang, which here runs between high banks (see map). A road, which was at the time of inspection in very bad order, joined the river with the rail. To exploit bamboos from the Pyinmana forests would necessitate floating an average distance of 40 miles down the Ngalaik and its tributaries and 120 miles from the junction of the Ngalaik and Sittang to the mill at Myozo.

All chemicals, except possibly lime, would either have to be railed up from Rangoon, a distance of 186 miles, or brought up the Sittang in boats, as the river is sufficiently deep to allow boats of 25 tons burden to ply up to Myozo.

(6) *Outturn.*

A certain number of bamboos are exploited annually from the Pyinmana forests by purchasers and right-holders; in 1909-10 the number taken out by the former was 72,700 and by the latter the number is estimated at 300,000. Compared with many other divisions in Burma this is a very small number.

The possible outturn of Kyathaung and Tinwa bamboos is based on the enumerations made in the Pyinmana and Toungoo Divisions and on weighings taken of a large number of cut stems. It has been thought advisable to take the average of the countings in both Divisions, as the

forests in both localities are very similar, being situated on the eastern slopes of the Pegu Yomas.

From Appendix II it will be seen that the average yield of dry internodes of both Kyathaung and Tinwa is 39,047 lbs. or 17·6 tons per acre. The area of forests covered by these bamboos is 271,372 acres, giving a gross yield of 9,596,262,284 lbs. or 4,775,147 tons of dry internodes. Estimating that the forests can be cut over once in five years, the possible sustained yield of dry internodes works out at 955,029 tons per annum.

(7) *Lines of export.*

The bamboos will have to be dragged from two to three miles to the nearest floating stream, and thence floated down the Ngalaik and Yonbin Chaungs to the Sittang river. Floating is only possible in the rains, and even then only in times of flood. This would seem to rule out these forests as a suitable locality whence the raw material could be exploited; on the other hand, very large quantities of teak are floated down annually by these streams, and there appears to be no reason why bamboos should not also be extracted in the same way. Mr. Leete, the Divisional Forest Officer, expressed it as his opinion that the work could be carried out without difficulty. On the Sittang floating is possible throughout the year.

The only forest in which it is possible to exploit bamboos by carts is the Yanaungmyin Reserve, and this could only be done in the open season.

The various distances over which it will be necessary to float bamboos the forest to the Sittang are as follows, the distance from the junction of the Sittang and Ngalaik to the mill being 120 miles :—

(*i*) The Taungnyé Reserve, from 20 to 40 miles.
(*ii*) The Ngalaik Reserve, from 45 to 60 miles.
(*iii*) The Kaing Reserve, from 30 to 40 miles.
(*iv*) The Pozaungdaung Reserve, from 20 to 40 miles.
(*v*) The Yanaungmyin Reserve, 20 miles.
(*vi*) The Palwé Reserve, from 35 to 60 miles.
(*vii*) The Yonbin Reserve, from 25 to 50 miles.
(*viii*) The Minbyin Reserve, from 29 to 50 miles.

At present the rafting work on the Ngalaik and Yonbin is done by local men, two men bringing down a raft of 150 Kyathaung, or of 200

Tinwa. On reaching the Sittang the rafts are enlarged and contain 1,000 stems or over.

(8) *Cost of cutting and extraction.*

The price of bamboos in Pyinmana is Rs. 5 to Rs. 6 per 100 for Kyathaung in the rains and Rs. 8 per 100 in the open season. Tinwa are generally sold at a little over half that rate.

The cost of cutting and dragging to the river, an average distance of 1½ miles, comes to Re. 1-8 per 100 for Kyathaung. The cost of floating, from the centre of the forest to the Sittang, costs Rs. 3-8 and the cost of floating in large rafts to the mill at Myozo is estimated to cost Rs. 2-8. The total cost of landing Kyathaung at the mill, therefore, works out to Rs. 7-8 per 100. Tinwa being much smaller and more easy to handle, the total cost is put at Rs. 6 per 100.

(9) *Cost of landing dry internodes per ton at the mill.*

From Appendix II, it will be seen that a Kyathaung bamboo yields 25·6 lbs. and a Tinwa yields 12·05 lbs. of dry internodes. Therefore, it takes 87 Kyathaung and 186 Tinwa to make up a ton of dry internodes. The cost of exploiting 100 Kyathaung to the mill costs Rs. 7-8 and of 100 Tinwa Rs. 6, so that the cost of landing one ton of dry internodes of Kyathaung at the mill works out to Rs. 6-8-5 and of Tinwa to Rs. 11-2-6.

(10) *Labour.*

The general opinion of the local officers is that sufficient labour will be forthcoming in the rains to exploit one and a half million bamboos and that petty contractors will be found to do the work. If more labour is necessary it will have to be imported. The price of labour is 8 annas per man, but in the harvest season it is generally higher. Burman carpenters and masons are procurable at Re. 1 per day, while Chinese carpenters can earn as much as Rs. 2 per day.

(11) *Chemicals.*

The cost of lime is 8 annas per 100 lbs. in Pyinmana. It is procured from a village called Chaungza, in the Paunglaung Range, about 6 miles east of the railway. The lime-stone is obtained from surface workings,

20 to 25 kilns being worked by the local population. The strata are said to be fairly extensive, and the lime is of excellent quality, though the former statement requires verification.

(12) *Fuel.*

As the proposed factory site is in the Toungoo Division the question of the supply of fuel must be considered for that locality. It is plentiful and can be brought down by boat to the mill door at a cost of Rs. 8 to Rs. 10 per ton.

(13) *Miscellaneous.*

The Pyinmana forests contain large quantities of pyinkado, a timber that does not float, and it has been suggested that, if this were sold, the bamboos required to float it out might afterwards be used as raw material for the manufacture of paper-pulp. The mill site suggested at Myozo lies in the wet zone but is, generally speaking, not unhealthy, and is a quiet and suitable place for Europeans to live in, provided proper accommodation is available. The Pyinmana forests are not healthy in the rains, especially during November, though the large firms working out the timber in these forests employ European supervision throughout the wet season.

BURMA BAMBOO AREA NO. IV. (*See portion marked* ***D*** *on map*).

Toungoo Division.

(1) *Name and Situation.*

(*i*) *Areas to the west of the Sittang river.*

The main ridge of the Pegu Yomas runs parallel to the Sittang and the railway at a distance of 50 miles. Between the hills and the river occur 14 Forest Reserves, the main block lying up against the hill range, while outlying blocks occur nearer, though never touching the Sittang river. The whole of these forests are drained by feeders of the Sittang, of

which the Kabaung and the Swa are the most important for floating purposes (see map). Of the 14 reserves, only four are suitable for the extraction of bamboos, namely, the Bondaung and Kabaung in the south drained by the Kabaung tributary and the East Swa and Saing Yané Reserves drained by the Swa. The other reserves are either too distant or are drained by rivers in which floating is difficult.

(ii) Areas to the east of the Sittang river.

To the east of the main stream are found four reserves of small size; moreover, there are extensive areas of unclassed forest containing many bamboos. The most important tributary on this side of the river is the Thaukyegat, which joins the Sittang near Toungoo. This river drains extensive Unreserved Forests. To the north of this river, there are six small tributaries in the Toungoo Division, all of which pass through Unreserved Forests containing bamboos.

(2) *Description of the forests.*

The four blocks to the west of the river, with which this scheme deals, are situated on hilly ground, rising in places to over 1,000 feet. The northern portion of the Bondoung Reserve is drained by the Kabaung, while the southern portion is drained by a small tributary down which it would be difficult to float bamboos and so it has been excluded from the bamboo-yielding area.

The Kabaung reserve, which lies to the west of the above reserve, is drained down the centre by the river of the same name. It is not possible to extract bamboos from the whole reserve, as the Kabaung is a rocky stream above its junction with the Kyetsha Chaung.

Both blocks contain dry to moist deciduous teak, pyinkado and bamboo forest, the chief species of bamboo being *Bambusa polymorpha* (Kyathaung), while *Cephalostachyum pergracile* (Tinwa) also occurs in fair quantities, but is still immature having flowered in recent years. The type of forest in the two northern blocks, on the Swa River, resembles that in the Kabaung Reserve, but is somewhat drier, the East Swa Reserve being drained by the main stream and its tributary the Lonyan Chaung, while the Saing Yané Reserve is drained by a tributary known as the Saing Chaung, which in its upper reaches is not a good floating stream.

To the east of the Sittang, the Thaukyegat Chaung is the most important tributary and drains extensive areas of Unreserved Forests, containing much pyinkado and bamboos, as also in places "Indaing" (*Dipterocarpus tuberculatus*) in which the bamboo is scarce or entirely absent. To the north of this river occur smaller forests from which a certain number of bamboos could also be exploited.

(3) *Area.*

The reserved forests of this Division are very extensive and contain masses of bamboos. As was mentioned before, many of these forests are remote from good floating streams or floating is not practicable along some of the larger rivers, such as the Pyu and Kun, owing to the presence of rocky gorges where they enter the plains. For this reason, the areas from which bamboos can be exploited are relatively small as compared with the total areas under forest.

The forests from which bamboos can be extracted are as follows:—

Name of Reserve.		Actual area of Reserved Forests, in acres.	Forests from which bamboos can be exploited, in acres.
Kabaung drainage	Bondaung Reserve . .	23,757	10,330
	Kabaung Reserve . .	188,934	17,240
	Unreserved Forest . .	Not known.	10,000
Swa drainage	East Swa Reserve . .	13,555	....
	Lower Saing Yané Reserve	70,176	15,000
Thaukyegat drainage.	Unreserved Forest, east of the Sittang.	Not known but very large.	10,000
Drainage of six small feeders of the Sittang.	Unreserved Forest on east bank of the Sittang and north of Toungoo.	Ditto .	12,000
		..	74,570

Both Mr. Rorie, the Divisional Forest Officer, and the writer of this report consider the estimate of 74,570 acres to be a low one, and well on the safe side.

(4) *Species of bamboos and mode of growth.*

By far the most abundant species of bamboo found in the Toungoo forests is *Bambusa polymorpha* (Kyathaung). It grows here to a large size, averaging 49 feet long when cut off at 2″ girth at the thin end and with a mid-girth of 10·1″: *Cephalostachyum pergracile* (Tinwa) comes next in importance after Kyathaung. This species flowered about 1905, the old clumps after producing seed died down and at present the ground is covered with seedlings which in a few years will produce large quantities of bamboos.

Bambusa Tulda (Thaikwa) and *Dendrocalamus strictus* (Myinwa) occur locally in fair quantities but are not nearly so abundant as the first two species mentioned.

(5) *Factory site.*

The factory site is the same as that proposed for the Pyinmana scheme, namely Myozo, some 18 miles down the Sittang from Toungoo. (See map.)

(6) *Outturn.*

The number of bamboos exploited in 1909-10 from the Reserved and Unreserved Forests of the Toungoo Division was as follows :—

From Unreserved Forests.

Range.	Locality.	Number.	Rate.	Amount.
			Rs. a. p. per 100	*Rs. a. p.*
Pyunchaung . .	Unreserved . . .	200,200	0 5 0	625 10 0
Pyu . . .	Ditto . . .	258,700	0 5 0	808 7 0
Yedashé . . .	Ditto . . .	11,200	0 5 0	35 0 0
Thagaya . .	Ditto . . .	16,800	0 5 0	52 8 0
Gwethé . . .	Ditto . . .	149,500	0 5 0	467 3 0
Kabaung . .	Ditto . . .	192,700	0 5 0	602 3 0
	Total Unreserved Forests .	829,100		2,590 15 0

From Reserved Forests.

Range.	Locality.	Number.	Rate.	Amount.
			Rs. a. p. per 100	*Rs. a. p.*
Pyunchaung . .	Chaungmaugé Reserve .	300	0 5 0	0 15 0
,, . .	Mezindein Reserve .	12,000	0 5 0	37 8 0
Pyu . . .	Kauguthuri Fuel Reserve.	1,000	0 5 0	3 2 0
,, . . .	Myayabin Reserve .	2,100	0 5 0	6 9 0
Thagaya . .	Myohlabes ,, . .	20,900	0 5 0	65 5 0
,, . . .	E. Swa ,, .	38,000	0 5 0	118 12 0
,, . . .	Saing ,, .	8,400	0 5 0	26 4 0
Yedashé . .	Lonyan ,, . .	1,500	0 5 0	4 11 0
,, . . .	W. Swa ,, .	12,700	0 5 0	39 11 0
Gwethé . .	Gwethé ,, .	5,600	0 5 0	17 8 0
,, . . .	Kanin ,, .	3,100	0 5 0	9 11 0
Kabaung . .	Kabaung ,, .	47,200	0 8 0	236 0 0
	Total Reserved Forest	152,800	..	566 0 0
	GRAND TOTAL .	981,900	..	3,156 15 0

The possible outturn of Kyathaung and Tinwa bamboos is based on the enumerations made in the Pyinmana and Toungoo Divisions, the latter countings having been made by Mr. Rorie, the Divisional Forest Officer. The calculations of the weight of the green bamboos and dry internodes is based on weighments made of 200 average Kyathaung and 200 Tinwa bamboos, cut in the forests in which the enumeration plots were taken. From Appendix II it will be seen that the average yield of dry internodes of both Kyathaung and Tinwa is 39,047 lbs. or 17·6 tons per acre. The area of the forest, from which it is possible to exploit these bamboos, is 74,370 acres, giving a gross yield of 2,903,925,390 lbs. or

1,309,212 tons of dry internodes. Estimating that the forests can be cut over once in five years, the possible sustained yield of dry internodes works out at 261,842 tons per annum.

(7) *Lines of export.*

The bamboos will have to be dragged a maximum distance of two miles to the rivers after being cut, and floated down to the Sittang and again some 20 miles down that river to Myōzo, the proposed factory site. The chief floating streams are as follows :—

(*i*) The Kabaung, a large stream down which bamboos can be floated up to the end of February. This river taps the Bondaung and Kabaung Reserves. Above the point where its tributary the Kyetsha Chaung comes into the main stream, the bed is rocky, so that the area above this point has been excluded from this scheme. To overcome this difficulty of floating in streams with rocky beds, Mr. Walker, Burma Forest Officer, has suggested cutting up the bamboos into sections, each section to contain at least 2 internodes, so that an air-tight chamber occurs in each piece and then to float them down separately. This has never been done but would seem to be a by-no-means impossible way of getting over the difficulty.

(*ii*) The Swa river, which taps the East Swa Reserve, enters the Sittang some 40 miles above the proposed mill site at Myozo. Its tributary the Saing Chaung, which is also a large stream, taps the Saing Yané Reserve. It is a good floating stream down which bamboos can be brought from the village of Lonyānbauk up to the end of February.

(*iii*) The Thaukyegat is a large perennial stream on the east bank of the Sittang, and joins that river just below Toungoo. It possesses the great advantage in that bamboos can be floated down its channel throughout the year.

(*iv*) Bamboos can also be obtained by floating them down the other small streams which occur on the east bank of the Sittang, to the north of Toungoo.

(*v*) Small quantities of a few hundred tons can also be extracted by carts from the hill forests directly west of Myozo, the lead by road being not more than seven miles.

(8) *Cost of cutting and extraction.*

The present price of Kyathaung in Toungoo is Rs. 6 per 100 and Rs. 6 to Rs. 7 per 100 for Tinwa.

The cost of cutting and dragging Kyathaung to the floating streams is put at Re. 1-8 per 100; the cost of floating to the Sittang, from the centre of the Kabaung or East Swa Reserves, is estimated to cost Rs. 3-8 per 100; and the cost of preparing large rafts and floating them down the Sittang, an average distance of 30 miles, is put at Re. 1-8, giving a total of Rs. 6-8 per 100 landed at the mill. Tinwa, being smaller and easier to handle, can be brought out for Rs. 5 per 100.

(9) *Cost of landing dry internodes per ton at the mill.*

From Appendix II it will be seen that a Kyathaung bamboo yields 25·6 lbs. and a Tinwa yields 12·05 lbs. of dry internodes. Therefore it takes 87 Kyathaung and 186 Tinwa to make up a ton of dry internodes. The cost of exploiting 100 Kyathaung to the mill costs Rs. 6-8 and 100 Tinwa Rs. 5, so that the cost of one ton dry Kyathaung internodes at the mill works out to Rs. 5-10-6 and of Tinwa to Rs. 9-4-9.

(10) *Labour.*

Mr. Rorie, the Divisional Forest Officer, Toungoo, anticipates difficulty in procuring an adequate supply of labour, and it is fairly certain that it will be necessary to import coolies from outside the district. In order to indicate the wages now being paid at Myozo, the proposed mill site, it may be stated that a cooly earns Rs. 13 to Rs. 15 per month working at the Myozo Saw-mill, and that the Engineer-in-charge is paid Rs. 110 per mensem.

(11) *Chemicals.*

The cost of lime at Toungoo is 8 annas per 100 lbs. and this must be either procured from the Pyinmana Division (see page 58) or from Rangoon or Moulmein. It is just possible that the other necessary chemicals could be run up the Sittang in boats, but on this point it is difficult to make any statement with certainty. Otherwise they would have to be railed up from Rangoon to Kywebwé and carted two miles to Myozo.

(12) *Fuel.*

Fuel is plentiful in this Division, and a certain amount could always be procured from the many saw-mills along the Sittang. It can also be obtained by floating it down the river from the Unreserved Forests. It would probably cost from Rs. 8 to Rs. 10 per ton landed at the mill.

(13) *Miscellaneous.*

The remarks made on page 59 regarding the possibility of floating out bamboos in conjunction with pyinkado apply with equal force to this Division. The great advantage of utilizing these forests for the supply of raw materials lies in the fact that floating can be carried out throughout the year down the Thankyegat Chaung.

Myozo is a healthy place, though the forests during November and December are by no means healthy. The most difficult point to be settled is the labour question, about which it is difficult to obtain reliable information.

Burma Area No. V.

Arakan Division.

(1) *Name and Situation.*

The conditions which indicate the feasibility of extracting bamboo for paper-pulp in other districts of Burma, which have been described above, differ *in toto* in Arakan. The species of bamboo is different to that found in Burma proper, while the local conditions are peculiar to Arakan, and will therefore require to be described in detail.

The forests from which bamboos can be extracted cover the various catchment areas, the drainage of which finds an outlet at or near the seaport of Akyab (see map). This part of the district lies north and north-east of Akyab and is drained by three large rivers, namely the Mayu to the west, the Kaladan in the centre and the Lemru to the east. The Arakan coast-line here runs more or less north-west and south-east, while the three above-mentioned rivers run from north to south converging on Akyab, and are separated by parallel lines of hills rising to about

300 feet. Owing to the existence of a waterfall on the Seik Chaung, a tributary of the Mayu, which occurs about 60 miles from the sea and which it is thought, might possibly be utilized to generate power for a mill, this scheme has been divided into two parts. The first dealing with the forests lying above this waterfall, the raw produce from which could be worked out to a mill just below the falls, and the other dealing with the forests on each side of the Kaladan and Lemru, the bamboos from which could be exploited to Akyab.

A.—FORESTS OF THE SEIK CATCHMENT AREA.

(See small portion marked E on map.)

(2) *Description of the forests.*

The catchment area, in which these forests occur, is, generally speaking, narrow and long, the main stream having few feeders of importance throughout the area, except one on the east bank, called the Rhee Chaung, which is nearly as large as the main stream and joins it just above the waterfall. The forests were originally of an evergreen type but this class of forest has gradually disappeared and is now found only along the banks of the rivers and on the steeper slopes. The rest of the area is now covered with a dense crop of bamboos, known locally by the name of Kayin (*Melocanna bambusoides*), in which practically not a single tree is to be seen. This peculiar type of bamboo growth has been brought into existence by a method of shifting cultivation known as "Taungya." It is carried out by the hillmen and consists in cutting down the original forests, burning the timber and brushwood when dry and sowing rice and cotton seed in the ashes; they then desert the place, after reaping the crop, and go on to another area. As this system of cultivation has been going on for many generations, the original forests have practically disappeared, leaving these hill tracts covered with masses of bamboos of varying ages.

Each household cuts about three acres a year, and now that the people have cleared out the virgin forests, they go back every six or seven years to their original area and instead of cutting and burning tree growth, which has, as a matter of course, disappeared, they clear out the six to seven-year old bamboos, and burn them in order to obtain the ash in which to sow the seed.

(3) *The area of forests covered by bamboos.*

The areas dealt with are not organised ; in other words, no Working-Plans have been prepared, so that the exact size of the catchment area of this river is not known. From the available maps it would appear to be about 150 square miles, of which 90 square miles may be taken into account, from which it is possible to exploit bamboos, namely, one mile on each side of the river, from a point above the waterfall and similarly one mile up each side of its tributary, the Rhee Chaung. This figure has been arrived at after inspecting the greater portion of the whole area.

(4) *Species of bamboo and mode of growth.*

The species found in these forests is *Melocanna bambusoides*, with a comparatively small thin-walled stem, which does not grow in clumps, like most other bamboos, but sends out shoots from a ramification of rhizomes in the same way as suckers are put out by tree roots. The result of this mode of growth is that the ground is covered with stems standing at more or less equal distances, one from another, and not in clumps, as is generally the case with such species as *Cephalostachyum pergracile* or *Bambusa polymorpha*. A number of stems were measured on a recently cut " taungya " area, which was covered with seven-year-old growth, and were found to average 20·1* feet in length and 3·0″ mid-girth. Another lot numbering 10,575 was cut by Mr. Walker, Divisional Forest Officer, Arakan, and gave an average of 22 feet in length and 3·8″ mid-girth (see Appendix III).

As has been mentioned above, the bamboo forests contain blanks under cultivation, and elsewhere growth of one, two, three, and up to seven-year-old bamboos, each age-class being separate. The one-year-old growth is about 12 feet high, the second about 15 feet, until at seven years of age it is from 30 to 35 feet high.

(5) *Possible factory site.*

The reason for dividing this scheme into two parts is that there occurs a fine waterfall on the Seik Chaung, above the village of Ponnyaleik, the fall being some 60 miles up the river from Akyab, while the other two catchment areas in this part of the country drain down direct to that town and could therefore not be conveniently worked out to a mill

*NOTE.—The thin end having been cut off before the culms were measured.

situated just below the falls. In the event of the falls being utilized for the purpose of working a pulp-mill, the site could be chosen below the falls and the area above utilized for the extraction of the bamboos.

The falls are situated on the Seik Chaung, shown on the map south of the smaller portion marked E, and just outside the bamboo area. The Seik Chaung is a large tributary of the Mayu river, and at the place, where they meet, the river is about 200 yards broad. The falls themselves consist of three steps, the upper one having a drop of 16 feet and separated from the second by a sloping ledge 300 yards long, falling some 14 feet over its length. The middle falls are 30 feet high and are divided from the third or lower fall by a stream 100 yards in length, which drops 20 feet, the lower cascade being about 10 feet in height. The total fall of the river over a distance of 400 yards, is therefore about 90 feet.

The cause of these falls is due to a peculiar formation of rock running at right angles across the river like a wall, a feature which is especially marked on the upper falls, so that there would be little difficulty in training the stream in order to concentrate the flow of water into one channel. On either side of the falls, the banks of the stream are precipitous, especially on the west side; on the east bank, there occurs a ledge or spur along which the water could be taken, were the stream to be tapped at the upper falls. This ledge runs down the east bank for about half a mile and emerges on to a fairly level stretch of open ground, on which a mill could be erected.

During the monsoon months a great volume of water passes over these falls but diminishes as the dry season advances. At the time when these falls were inspected, at the beginning of February, the stream flowing over the central falls was about 40 feet broad with a very fair volume of water coming over. In the event of these falls being taken into consideration as a possible power station for a pulp-mill, it would be necessary for the interested parties to send an engineer to inspect them during April, so as to ascertain the power available during the dry months.

The proposed site below the falls has also the great advantage that large lighters and small steamers can come up to this point throughout the year at high tide, and thus connect up the place directly with the seaport of Akyab.

Lastly, fresh water is obtainable at this place in large quantities which is a distinct advantage, especially in a locality where most of the streams are tidal for long distances up from the sea.

(6) *Outturn.*

A sample plot was taken by Mr. Walker, Divisional Forest Officer, Arakan, in which he clear cut exactly one acre of bamboo growth, and counted and weighed all the stems. The results of this operation are given in Appendix III. As the nodes in this species of bamboo are very small, they have not been taken into account as both internode and node can be pulped together. The yield, per acre, of dry stems is 16,576 lbs, the area from which bamboos can be extracted is estimated to be 57,600 acres, so that the gross yield works out to 426,240 tons. Working on a seven-year-rotation we get an annual sustained yield of 60,891* tons.

Though the quantity of bamboos stated above could be exploited annually, at present the whole of the bamboo forests are worked over by the Taungya cutters who monopolise the whole areas, so that, unless these cutters were largely restricted or entirely turned out, there would be no place for a mill. The Taungya cultivators leave a surplus which would be available for the mill but it would not in any way be sufficient to keep it running throughout the year. It would, therefore, be imperative for the interested parties to approach the Burma Government before prosecuting further enquiries in this locality.

A possible solution to the difficulty would be to employ the Quamis who cultivate this area, in cutting and extracting the bamboos, though it would have to be borne in mind that they are a hill tribe knowing little about contract obligations and therefore could not be relied upon, until they had been taught to work more methodically than at present.

(7) *Lines of export.*

The Seik Chaung, down which the bamboos can be floated to the falls, is 50 yards wide, 30 miles above the proposed mill site, increasing to 200 yards at the falls. Over the upper 25 miles of its course it is a deep channel flowing slowly between steep banks, covered with dense evergreen forest. These forests are, however, only a fringe along its banks, while the hills above are covered from end to end by a dense pure crop of bamboos.

*NOTE.—This is thought to be an extremely conservative figure.

The last five miles to the falls are a series of cataracts divided by deep holes, the bad portions of the channel being more or less divided into three sections. At present, bamboos are floated down the entire length of the river, being dragged over the rocky portions, while, at the main falls, they are thrown down and collected into large rafts in the deep pools at the foot of the falls. Without doubt, the stretches, over which floating is at present difficult, could be greatly improved by clearing the main channel of boulders and rocks, and this at no great expense. The stream in February was found to be broad and the amount of water was quite sufficient for rafting purposes. Probably for two months of the hot weather, dragging would be necessary over short lengths of difficult channel within five miles of the main falls.

The stream below the falls is deep and broad so that a pulp- mill, situated on the east bank of the river, would be in direct communication by water with Akyab, a port that large steamers can enter throughout the year.

(8) *Cost of cutting and extraction.*

The Seik Chaung, above the falls, has a long narrow catchment area, so that, the distance, over which the bamboos will have to be dragged to the stream, will not exceed one mile. On the other hand, with the exception of the Rhee tributary, there are few by-streams down which floating is possible. The present cost of extracting bamboos to the falls is Re. 1 per 100; were work to be carried out on a large scale, under proper supervision, the cost could no doubt be reduced. The price of bamboos in Akyab is at present Rs. 2 per 100.

(9) *Cost of landing dry stems per ton at the factory site.*

The weight of 10,575 dry stems is 16,576 lbs. so that 100 stems weigh 155 lbs. The weight of the nodes, as before stated, need not in this case be taken into consideration. It therefore requires 1,452 bamboos to make one ton. The cost of landing 100 bamboos at the falls is Re. 1, so that the cost of one ton of bamboos at the proposed factory site, *i.e.*, just below the falls, comes to Rs. 14-8-1.

(10) *Labour.*

It is probable that, if Government decides to stop Taungya cutting in any given area, it will insist on a serious attempt being made to employ

the local cutters in felling and extracting the bamboos. In any case Chittagong coolies, who come over in great numbers during the harvest season, would be available. A labourer can earn 8 annas a day and during the rice harvest probably double that amount.

(11) *Firewood.*

Were the falls utilized for working a power station, a considerable reduction could be made in the amount of fuel required.

(12) *Chemicals.*

Good lime is available from Ramree Island, close to Kyaukpyu, a fair quantity of which is annually imported to Akyab, where it fetches Rs. 65 per 100 maunds (80 lbs. per maund). It is probably possible to obtain coral outside Akyab harbour, but this point requires verification. All other chemicals necessary will have to be imported by sea to Akyab port.

(13) *Miscellaneous.*

The whole scheme is based on the assumption that Taungya cutting will be restricted or stopped, otherwise all hope of success must fall to the ground. The area and local conditions appear to be admirably suited for the purpose of the pulp-mill, as dense forests of bamboos occur in this catchment area, the river is well suited to floating, especially if the channel just above the falls is improved, big boats can come right up to the proposed mill site from Akyab, the cost of extraction is not prohibitive, while the waterfall may quite possibly be found suitable for working a mill.

B.—FORESTS OF THE KALADAN AND LEMRU CATCHMENT AREAS.

(*See large portion marked E on map.*)

(1) *Description of the forests.*

The Kaladan and Lemru are two large streams, having their sources far up in the Arakan Hill Tracts, flowing southwards between parallel ranges of hills and both finding an outlet at the sea-port of Akyab. The

Kaladan is the larger of the two streams, with several large tributaries, the most important of which are the Yo and Pi Chaungs on its west bank, and the Mi Chaung on its east bank. It is navigable for large launches up to Paletwa, some 100 miles from its mouth.

The Lemru lies to the east of the Kaladan and is navigable up to a point about 60 miles from the sea. It has many large tributaries, the most important of which are Tagwé, Wat and Than Chaungs on its east bank and the Ru Chaung on the west bank. Both the Kaladan and Lemru pass through bamboo forest in the upper half of their courses, while their tributaries tap extensive bamboo areas in the by-valleys. The type of forest in these localities is the same as that described in Part A being, generally speaking, covered with bamboos resulting from "Taungya" cutting.

(2) *Area of forest covered with bamboos.*

The area of Protected Forest north of Akyab, as given in the Administration Reports, is 8,050 square miles. It is not possible to state, with accuracy, what portion of this is covered by bamboo growth, but from the general aspect of the country it is put at 3,000 square miles, which is probably a low estimate.

(3) *Species of bamboo and mode of growth.*

The species of bamboo, its mode of growth, and the system under which the forests are worked by Taungya cutters, are the same as described in Part A.

(4) *Possible factory site.*

In this case the proposed site is at Akyab, for the reason that both rivers find an outlet at this port, and that the bamboos from both areas can be brought down to this place without difficulty. The chief difficulty, which presents itself here, is the supply of fresh water, as the only source available is a tank which supplies the town. At present the quantity available is hardly sufficient for domestic purposes, and a scheme has been started to increase the supply, so that there will be about one million gallons in excess of what is necessary for the town of Akyab. This amount would not be sufficient for a pulp-mill, so that further storage tanks would have to be prepared. Otherwise Akyab presents many advantages, being a good port and geographically well situated.

(5) *Outturn.*

It is not possible to give any figures of outturn for these localities. The conditions described in Part A of this scheme apply to these forests, namely, that the bamboo growth is cut over by Taungya cutters every 6th or 7th year, and that the bamboo forests are monopolized by them for this purpose. On the other hand, as the area of forest is in this case very large, the surplus supply of bamboos, over and above that utilized by Taungya cutters, is considerable. As an instance in proof of the above statement, it may be pointed out that the amount taken out in 1908-09 to meet the local demand amounted to 779,900 stems from the Kaladan and 1,050,300 from the Lemru catchment areas.

To obtain a large supply of bamboos, it would be necessary to go far up into the hills, as the local supply, which is obtained from the balance left over by the Taungya cutters, comes from areas relatively close to Akyab.

Owing to want of time, it was only found possible to carefully inspect the Seik catchment area, so that in the event of any persons wishing to go further into the matter, a more detailed enquiry into the Kaladan and Lemru catchment areas would be necessary.

As stated above, it is not possible to give definite figures of outturn, as it is not known what amount will be available after the "Taungyas" have been cut each year and the local demands have been satisfied. It must, however, be considerable, and it is thought that a sufficient quantity will be available to run a large pulp-mill. Were the "Taungya" cuttings restricted or stopped, the supply would be enormous.

(6) *Lines of export.*

Floating is feasible throughout the year, even in the upper reaches of the Kaladan, the Lemru and their tributaries; in this connection no difficulties are anticipated.

(7) *Cost of cutting and extraction.*

The price of bamboos at Akyab is from Re. 1-12 to Rs. 2 pe 100. This includes cost of extraction, floating, profit to the contractor and 5 annas for royalty. Were bamboos to be exploited on a large scale, they could be landed at Akyab at Re. 1-8 per 100.

(8) *Cost of landing dry internodes per ton at the mill.*

From weighments of ten-year-old dry bamboos taken by Mr. Walker (see Appendix III) a dry bamboo was found to weigh 1·55 lbs., so that it requires 1,452 bamboos to make a ton. The price is Re. 1-8 per 100 at Akyab, so that the cost of one ton of raw material comes to Rs. 21-12.

(9) *Labour, firewood and chemicals.*

The notes made in Part A, under these headings apply with equal force to this portion of the Arakan scheme.

(10) *Miscellaneous.*

In this instance, the scheme is not so much based on the assumption that Taungya cutting will be stopped or restricted, as on the existence of a surplus quantity of bamboos being available after the Taungya cutters have been supplied with their requirements. Such a stand-point was impossible in the case of the Seik catchment basin, as the area there is comparatively small and the surplus small in proportion. In the Kaladan and Lemru catchments, the area covered with bamboo is very much greater, so that the available surplus must necessarily be far greater than is the case in the smaller area.

There appears to be only one drawback to Akyab as a possible factory site, and that is the question of fresh water. This might possibly be overcome by utilizing water from the tank supplying the town: the supply could be further helped out by preparing storage tanks, a quite feasible proposition when it is taken into consideration that the annual rainfall in this locality is over 200 inches.

POSSIBLE SITES FOR BAMBOO PAPER-PULP MILLS IN THE BOMBAY PRESIDENCY.

NOTE.—Since these areas were inspected, flowering of the Daugi bamboo has been reported to have taken place but to what extent is not known. This may render some of the areas unworkable for a few years, though the period required for recovery is generally short.

AREA NO. I. (*See portion marked* **A** *on map.*)

The Gangavalli Catchment Area in the Ankola and Yellapur Ranges of the West and East Kanara Forest Divisions.

(1) *Name and Situation.*

The area is situated on the West Coast of the Bombay Presidency in the Kanara Collectorate and comprises the catchment area of a large river, known as the Gangavalli in its lower reaches, and as the Bedti River where it pierces the Ghats. The valley formed by this river is fairly broad, for a distance of 8 to 10 miles from the coast, and gradually narrows as it approaches the Western Ghats, which lie some 40 miles from its mouth. On its course down the Ghats it passes through narrow gorges and forms a rushing stream, with many small waterfalls. On the plateau it is a narrow stream which in its upper reaches nearly dries up in the hot weather. From the sea to the foot of the Ghats the river is bounded on each side by high spurs and chains of hills jutting out of the Deccan plateau, which gradually disappear on approaching the coast. Small tributaries coming from the surrounding hills flow into the river on either side.

(2) *Description of the forests.*

The forest is what is known as moist deciduous. It contains a great variety of species, intermixed with large quantities of bamboos, of the species known as *Bambusa arundinacea* (Daugi), which, though it occurs nearly all over the area, is especially abundant on the more level ground on each side of the main stream and up the by-valleys. The finest growth is found in the upper limits of the valley round the Ramangulli, Arbail and Shavkar cultivations, and everywhere along the banks of the streams. On the slopes the growth is less luxuriant and the clumps

Pearson.—Utilization of Bamboos in the Manufacture of Paper-pulp.

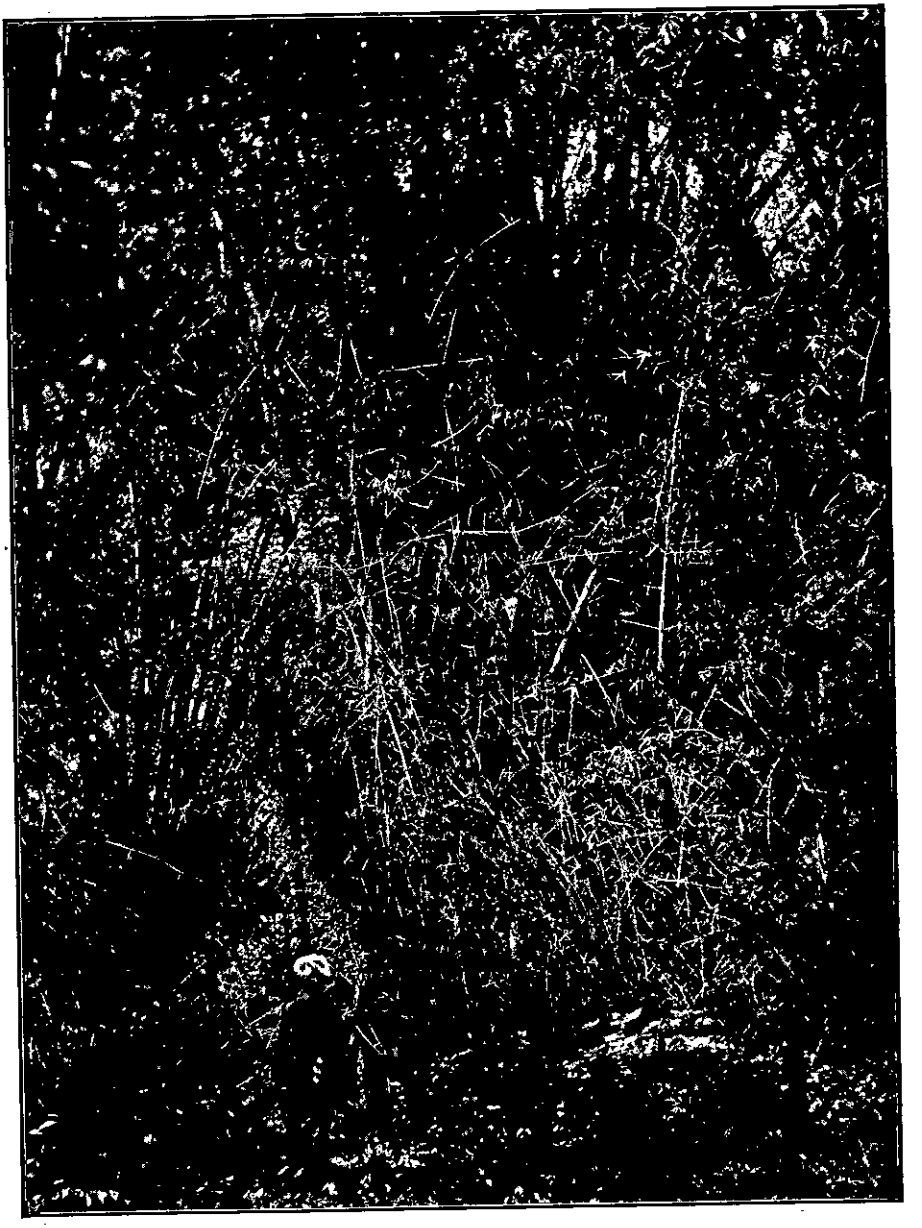

Photo.-Mechl. & Litho. Dept., Thomason College, Roorkee.

Photo by R. R. Chandilkar, Forest Surveyor.

Bambusa arundinacea Forest, West Kanara Forest Division, Bombay Presidency.

more scattered, being generally denser along the dry rivulets than on the faces of the slopes.

(3) *Area of forest covered by bamboos.*

The area covered by bamboos which can be worked out to the main stream is 68,723 acres, of which 38,643 acres have been classified as first class bamboo area, and 30,080 acres as second class, owing to the relative poorness of the crop. From the map will be seen the general position of the area with reference to the coast-line.

(4) *Species of bamboos and mode of growth.*

The chief species occurring in the area is *Bambusa arundinacea*, a large bamboo, which in the more favourable localities above referred to grows 60 to 80 feet in height and 8 inches mid-girth. In the 2nd class areas it is about 30 feet in length and 6 inches mid-girth.

The number of clumps, obtained by counting six sample plots in 1st class area worked out to 64 per acre, containing a total of 149 new culms under one year old and 306 culms over one year old or a total of 455 culms per acre. These figures are taken into consideration hereafter in calculating the possible yield. A very marked feature in the growth of this species of bamboo is the sheath of the side-shoots, armed with recurved points, resembling thorns, which forms a complete palisade to a height of 6 to 8 feet from the ground round each clump, and which renders extraction more difficult than is the case with the unarmed species.

(5) *Possible factory site.*

The most suitable factory site is at the village of Gumbala situated on the banks of the Gangavalli, above the tidal level, some 14 miles from the sea (see map).

The area, in which the bamboos are most plentiful, starts just above Gumbala and stretches for 24 miles up the valley to the village of Arbail at the foot of the Ghats. The stream is suitable for floating over its entire length, except during the summer months, and possibly during the first two months of the rains. There exists a small Bunder or port on the coast, on a neck of land jutting into the sea, south of the mouth of the river at Tadri, which is a calling place for

Shepherd's steamers. The river at Gumbala is some 200 yards broad, and always contains a plentiful supply of fresh water, while small boats of 5 tons burden can reach it from the sea. It is for this reason, as also from the fact that the place is fairly healthy and open, that it has been chosen as a suitable site for a pulp-mill.

(6) *Outturn.*

The outturn is based on the eight sample plots taken in different parts of the area. The work was carried out by Mr. Miller, the Divisional Forest Officer, his Assistant Mr. Kotwal, and the writer of this report, when the latter was on tour in that District. Owing to the bamboo growth being heavy on the more level ground and lighter on the slopes, it has been considered necessary, for greater accuracy, to divide the forest into two quality areas.

The total area of bamboo-yielding forest is computed at 68,723 acres, the figure having been arrived at by the use of a planimeter. Of this, 38,643 acres are first class and 30,080 acres are second class bamboo forests. Referring to Appendix IV, sample plots Nos. 1 to 6, we get 10,149 lbs. per acre as the average outturn of dry internodes in first class areas, and from sample plots Nos. 7 and 8, 1,975 lbs. per acre in the second class areas. The total gross yield for the whole area, taking into consideration the areas of the two quality classes and their yield per acre, therefore, works out to 451,595,807 lbs. or 201,605 tons. The question as to a suitable rotation on which to cut bamboos has been already discussed in Part II, and has been fixed at 5 years, so that the total sustained yield of dry internodes works out to 40,321 tons per annum. As it will probably be found possible to treat the nodes together with the internodes the annual yield may be raised by 15 per cent.

(7) *Lines of export.*

There are two methods by which the bamboos can be exported (1) by floating down the Gangavalli river and (2) by carting along the Yellapur-Karwar road which runs down the entire length of the valley close to the river. It would be necessary to drag the bamboos to the edge of the river or road, a maximum distance of three miles, but, generally speaking, not one-third of that distance, and afterwards either to float them in rafts down the river or cart them along the road.

It would, however, only be necessary to resort to the latter method in time of high flood or during the summer months.

(8) *Cost of extraction.*

(*i*) *By floating.*—Owing to the thorny palisade above-mentioned, which exists round each clump, the cost of cutting is estimated at Rs. 6 per 100, which is a high figure, the cost of dragging to the river is put at Rs. 3 per 100, and the cost of floating down the river from the centre of the area to Gumbala is put at Rs. 2 per 100, a total of Rs. 11 per 100.

(*ii*) *By carting.*—The average distance is estimated at 12 miles by cart-road. A cart holds 33 bamboos and the rate per cart is 2 annas a mile. This works out to Rs. 6-12 per 100 by cart, to which must be added Rs. 9, the cost of cutting and dragging to the road, which works out to a total of Rs. 15-12 delivered at Gumbala. To this must be added royalty charges. The price of bamboos on the coast is Rs. 10 to 12 per 100, of 20 feet length.

(9) *Cost of landing air-dry internodes per ton at the factory.*

From the results obtained by weighing culms cut in the sample plots (see Appendix IV), we get the following figures :—

Total number of culms cut.	Total weight air-dried, in lbs.	Weight of nodes and saw-dust, in lbs.	Weight of air-dried internodes, in lbs.	Weight of dry internodes per 100 culms, in lbs.	Number of culms required to yield one ton of dry internodes.	Cost of one ton of dry internodes at Gumbala.
554	16,234	2,372	13,862	2,502	89·5 in round figures 90.	Rs. 9-14-5 by floating and Rs. 13-8-0 if carted.

The above calculations are based on a fairly large number of culms cut from various parts of the area, in good, fair and indifferent bamboo forests. The culms were weighed green, and again after the nodes had been cut out and the culms had been allowed to dry for about four months.

(For details see Appendix IV.) The cost of landing dry internodes at Gumbala works out roughly to Rs. 10 per ton, which figure probably could be reduced considerably by working on a large scale and after further experience.

(10) *Labour.*

Part of the cooly labour could be procured from the coast villages, but importation of labour on a fairly extensive scale would be necessary, especially during the harvesting season, when the local population return to their homes to reap the rice crop. The price of labour is 5 to 7 annas a day for men and $2\frac{1}{2}$ to 3 annas for women and children. As regards the artisan class, with the exception of carpenters and a limited number of masons, they would have to be imported.

(11) *Chemicals.*

All chemicals, with the exception of lime, will have to be imported. The cost, however, would not be heavy as they can all be brought by sea and by sailing boats up the river. Large quantities of excellent shell-lime are available on the coast at a cost of 12 annas per cwt.

(12) *Fuel.*

Firewood is plentiful and can be obtained from the area in which the bamboos are found. The price fluctuates considerably, being generally high, owing to the proximity of the Bombay market. The price of coal would be very much the same as in Bombay.

(13) *Miscellaneous facts.*

Climate is an important factor in considering the suitability of a paper-pulp factory site. The upper reaches of the valley are, without doubt, very malarious during the winter months. On the other hand, the coast country and the country as far inland as Gumbala, is healthy, and quite fit for Europeans to live in throughout the year. The supply of meat food is very deficient, though fowls and excellent fish are always procurable.

AREA NO. II. (*See portion marked B on map.*)

The Kala Nadi Catchment Area in the Karwar and Supa Ranges of the West and North Kanara Forest Divisions.

(1) *Name and Situation.*

The area is situated on the West Coast of the Bombay Presidency in the North Kanara Collectorate and consists of the catchment area of a river known as the Kala Nadi, which taps the upper slopes of the Western Ghats and finds its way to the sea at Karwar, the head-quarters of the District and a small port, situated in a very fine bay. The valley, formed by this river, is fairly broad and open as far as Kadra, some 20 miles from the sea, and in this area, which is under cultivation, there are relatively few bamboos, except along the banks. Above Kadra the valley gradually narrows in, until above Bobrigadda it forms a ravine, through which the river passes in a deep channel some 100 yards broad. The hills, on each side of the river above Kadra, rise to over 2,000 feet and are clothed throughout with fine high forest. The village of Bobrigadda is about 40 miles from the sea. Above this village, the river, which is still a fine one, passes through the Gund slopes to the foot of the Ghats. The slopes on either side are covered with heavy teak and bamboo forests. The extreme limits, from which it would probably be practicable to exploit bamboos, is 40 miles above Kadra, or a distance of 60 miles from the sea.

(2) *Description of the forests.*

In the lower reaches, especially near the river and up its tributaries, there occur moist deciduous forests, while the greater portion of the lower and middle slopes are covered with dry deciduous forest, containing, above Birkol village, a fair quantity of teak and bamboo forest. The higher slopes are generally covered with evergreen forest, in which no bamboos are found. The prevailing species of bamboo is *Bambusa arundinacea*, known locally as the "Daugi" bamboo. It grows to a large size in the lower areas and is still of fair size on the dry slopes, while, on the Gund plateau above, an area also included in this scheme, it is found growing to a great size. The other bamboos found in these forests are *Dendrocalamus strictus* and *Oxytenanthera monostigma*, of which the former species in particular is not common.

(3) *Area of the forests covered with bamboos.*

The total area in which bamboos are found between Kadra village and the Shivpur Nala, a stretch of the valley covering some 30 miles, is computed to be 20,374 acres. Of this, 14,264 acres are classed as 1st class, and 6,110 acres as 2nd class bamboo forest—the figures based on enumerations made in the Working-Plans. To the above figures must be added the Gund area, which is a continuation of the Kala Nadi forests, in which the Divisional Forest Officer, Mr. Copleston, estimates 7,000 acres to be of the 1st class, giving a total of 27,374 acres of bamboo forest.

(4) *Species of bamboo and mode of growth.*

The common bamboo in these forests is *Bambusa arundinacea*, growing from 60 to 80 feet in height and 8″ mid-girth in the lower parts of the valley and to an even larger size on the Gund slopes, while on the drier slopes it attains a height of 50 feet and 6″ mid-girth. It is found fringing the banks of the main stream throughout its length, and is plentiful on the more level ground, especially near Sulgeri, Birkol, Devkar and above Bobrigadda, as also in Gund, while on the warmer slopes of the hills, it is found in scattered clumps, being densest up the dry rivulets.

(5) *Possible factory site.*

The best place for a factory would be just above tidal level, on the north bank of the river between Kadra and Balamani villages. Here the river is over 100 yards broad and flows with a strong current throughout the year. Five-ton sailing boats come up daily to Kadra, and from there to the factory would be under two miles, or a total distance of under 24 miles from Karwar harbour. There would be no question of want of water near Balamani, as the river never approaches a state of dryness at any time of the year. There is also plenty of open land on the north side of the river, on which a large mill could be erected.

(6) *Outturn.*

In estimating the outturn of bamboos from these forests, it will be necessary only to consider *Bambusa arundinacea*, as the other two species, *i.e.*, *Oxytenanthera monostigma* and *Dendrocalamus strictus* are not found in sufficient quantities to justify their inclusion in the estimate.

The conditions in this valley are identical with those in the neighbouring Ankola valley, which have been discussed above, so that the figures obtained by enumerating sample plots in that area will be applied here also. The growth in the Gund area being considered superior to that in the Kala Nudi or Gangavalli valleys, separate enumerations have been carried out, with a view to obtaining more reliable results.

The area of 1st class bamboo forest in the valley proper is 14,264 acres, while the outturn, according to figures given in Appendix IV, show a yield of 10,149 lbs. per acre, or a total outturn of 144,765,336 lbs. or 64,627 tons.

The 2nd class area in the valley covers 6,110 acres. From Appendix IV, we see that the yield per acre in this class of forest is 1,975 lbs. per acre or a total yield of 12,067,250 lbs. or 5,387 tons.

In the Gund plateau there are 7,000 acres of 1st class forest. From the figures of the enumerations of five sample plots (see Appendix IV), it will be seen that the yield of dry internodes per acre is 28,968 lbs. giving a total yield of 202,776,000 lbs. or 90,520 tons.

Therefore the gross yield stands as follows :—

	Tons.
1st class area in valley	64,627
2nd class „ „	5,387
Gund area	90,520
	160,534

As has been explained in Part II, the rotation is fixed at five years so that the sustained yield works out to 32,107 tons of dry internodes per annum. As explained under (6) Outturn, page 78, this estimate would be raised by 15 per cent. by including the nodes.

(7) *Lines of export.*

The Kala Nadi river is a broad stream which drains the whole area. Floating is possible from September to March and even later, as water flows in the channel throughout the year. Owing, however, to rapids above Kadra and again below Bobrigadda, floating is difficult unless the supply of water is considerable. In the case of the valley forests, the distance, from which bamboo will have to be dragged to the stream, never

exceeds two miles, while in most cases it will not be half that distance. In the case of the bamboos to be procured from the Gund plateau, which lies in the upper reaches of the river, they will have to be dragged a maximum distance of three miles to the edge of the plateau and then be slid down the steep sides of the Ghats to the river bank. There also exists a very fair road suitable for carts on the right bank of the stream from Kadra to Sulgeri, which is to be extended to Bobrigadda. The question of extraction, provided cooly labour is available, presents no serious difficulties.

(8) *Cost of cutting and extraction.*

As before stated, the extraction of the culms is rendered difficult owing to the palisade of thorns round the base of the clumps. The cost of cutting 100 culms is therefore put at Rs. 6 throughout. The cost of dragging to the river, a maximum distance of two miles, is put at Rs. 2 for the valley forests and Rs. 4 from Gund, while the cost of floating 100 bamboos from the centre of the area near Bobrigadda would be Rs. 2 and from Gund Rs. 5. The total cost of extraction, therefore, works out to Rs. 10 from the valley and Rs. 15 per 100 from Gund. The market rate for bamboos at Karwar, including royalty, is Rs. 10 to Rs. 14 per 100, according to quality.

(9) *Cost of landing air-dried internodes per ton at the factory site.*

The figures for the valley forests are taken from paragraph 9, page 79, of the Ankola valley scheme, and as the cost of landing green bamboos at Balamani is Rs. 10, the cost of delivery of the dry internodes at the factory site, obtained from the valley forests, works out at Rs. 9 per ton. Separate figures for Gund are given in Appendix IV. The internodes from one bamboo weigh 68 lbs, therefore the number of bamboos required to make a ton of air-dried tubes is in round figures 33, the cost of landing which at the factory site comes to Rs 4-15-2. The reason why it is cheaper to deliver one ton of air-dried internodes from the further area is that the individual culms from that area (Gund) are much larger and heavier than those found in the valley forests, while the actual labour required for their extraction is not in proportion to their size owing to the facility of floating them down the river.

(10) *Labour.*

No great number of coolies is available in the neighbourhood, as the coolies, who are in the habit of working in the forests, are employed in working the fuel coupes. It would, therefore, be necessary to import labour from Goa territory, Ratnagiri District and Savantwadi State. Cooly wages are from 4 to 7 annas a day, according to the season of the year, and women and children can earn 2½ to 3 annas a day. Carpenters and masons demand 12 annas to Re. 1 per day.

(11) *Chemicals.*

All chemicals, with the exception of lime, will have to be imported, though the cost of doing so will not be heavy, as they can be brought by sea to Karwar in steamers and in sailing boats of three to five-ton burden up the river as far as Kadra. Large quantities of excellent shell-lime are procurable on the coast, at a cost of 12 annas per cwt.

(12) *Firewood.*

Firewood is available in fair quantities, but it would not be sufficient to run a large mill. Coal would have to be imported, the price being about the same as in Bombay. The price of fuel is high, as much as Rs. 10 to 12 per ton, owing to the facility of export by sea to Bombay.

(13) *Miscellaneous facts.*

The climate in this valley is, on the whole better than in the neighbouring valley of Ankola, for which a scheme has been prepared in the foregoing pages. The climate in and around the proposed factory sites in both areas is about the same, but the upper reaches of the Ankola valley compare unfavourably with those of the Kala Nadi. A small port is situated at the mouth of the river at Kodibag, from which timber is exported up and down the coast. In the monsoon months the entrance is dangerous for ships, owing to the bar. The harbour is within two miles of Karwar, the headquarters of the North Kanara Collectorate, which is considered a healthy place for the West Coast.

Area No. III. (*See portion marked* **C** *on map.*)

The Mungod Forests of the East Kanara Forest Division.

(1) *Name and Situation.*

The area is situated on the Deccan plateau, stretching from the edge of the Western Ghats inland for a distance of above 20 miles. It is situated in the Yellapur and Mungod Ranges of the East Kanara Forest Division of the North Kanara Collectorate. The configuration of the land is characterised by an undulating plain, which is cut into by small rivulets, the southern portion being the upper catchment area of a river, known in its upper reaches as the Bedti and as the Gangavalli as it approaches the sea. The northern portion of the area is tapped by the Kala Nadi which runs more or less parallel to the Gangavalli, and finds an outlet into the sea at Karwar (see map).

(2) *Description of the forests.*

The area is covered with dry deciduous forests, while, here and there along the rivulets and on low-lying areas, evergreens occur. It is well stocked with trees and bamboos are found everywhere.

(3) *Area of the forests covered with bamboos.*

The whole area consists of bamboo forest of a practically uniform type. It has been divided into five blocks in the Working-Plan, of which the portions contemplated in this scheme are as follows :—

Block No.	Acres.
XIII	25,000
XIV	20,000
XV	21,000
XVI	8,000
XVIII (part)	5,000
XXIII (part)	34,000
Total	113,000

As the growth of the bamboos is fairly uniform throughout, the whole area has been grouped into one quality class.

(4) *Species of bamboos and mode of growth.*

The common bamboo in these forests is *Bambusa arundinacea*, which grows from 40 to 50 feet in height and 8″ mid-girth (see Appendix V). Portions of the area are densely stocked with this species and it is everywhere plentiful. It is not extracted to any great extent, the number taken out in 1908-09 being 14,500 only. The other bamboo found is *Dendrocalamus strictus* which, as compared with *Bambusa arundinacea*, is not plentiful, though fully sufficient to meet the local market.

(5) *Possible factory site.*

There are two possible factory sites. One is at Bomanhalli, also known as Kegdal, which is situated some five miles from the north-western limits of the area, on the Kala Nadi river. From the bamboo forest and leading to this place are several good cart-roads, while from the proposed factory site to Alnavar, a station on the Madras and Southern Mahratta Railway, is a high road, the distance being 26 miles. A plentiful supply of good water is found throughout the year in the Kala Nadi at Bomanhalli, so that, in many ways, the place is suitable for a factory site. The disadvantages are that it is out of the way and that though it is close to the bamboo forests, the distance over which supplies, chemicals and coal would have to be carted, is not only considerable but might present serious difficulties during the rains.

The other possible site is Hubli, a station on the Madras and Southern Mahratta Railway, an average distance of 35 miles from the centre of the forests. Three main roads, running through the area, go to Hubli, the gradients over their entire length being in no case excessive or long, as the country is everywhere practically flat. This place has several advantages over the Bomanhalli site. Hubli is a fairly large station, and also has a good climate, besides which, chemicals, coal and labour would be far more easily procurable.

(6) *Outturn.*

The outturn is based on *Bambusa arundinacea* only, as the other species are not plentiful, besides being already in considerable demand. Five sample plots were taken by Mr. Butterworth, Assistant Conservator of Forests, in blocks XIV and XV (see Appendix V) giving a yield of

5,461 lbs. of dry internodes per acre. The area of the forests is 113,600 acres, so that the total yield works out to 617,420,660 lbs. or 275,143 tons. By cutting over the area in five years the sustained yield works out to 55,028 tons of dry internodes per annum. The total may be raised 15 per cent. if the nodes are taken into account.

(7) *Lines of export.*

(*i*) *To Bomanhalli.*—The area is well supplied with roads. The Alnawar-Kadra main road runs through Bomanhalli. Block XIII is tapped by the Yellapur main road, 13 miles being the distance from the centre of the area to the factory site. Blocks XIV and XV are tapped by feeder roads, giving on to main road, a distance of 15 miles from Bomanhalli. The bamboos in blocks XVI, XVIII and XXIII will have to be carted over the Yellapur-Alnawar main roads, an average distance of 31 miles.

(*ii*) *To Hubli.*—Were Hubli taken as the site for the factory, the bamboos from blocks XIII, XIV and XV would have to be carted over the Yellapur-Hubli main road, a distance of 30 miles; those from blocks XVI, XVIII and XXIII by the Sirsi-Hubli main road, a distance of 40 miles.

The average distance of carting, therefore, works out to 18 miles in the case of Bomanhalli and 35 miles in the case of Hubli.

(8) *Cost of cutting and extraction.*

The cost of cutting 100 bamboos is put at Rs. 5, that is, one rupee less than was the case below the Ghats. The reason for this is that the culms are not so large in this locality as they are in the Karwar and Ankola forests. A cart can take 1,200 lbs. of bamboos. One hundred dry bamboos weigh 3,720 lbs. (see Appendix V), therefore 100 bamboos furnish three cart-loads. The cost of carting is $2\frac{1}{2}$ annas per mile, therefore the cost of carting 100 dry bamboos to Bomanhalli, an average distance of 18 miles, comes to Rs. 8-7 and to Hubli, an average distance of 35 miles, Rs. 16-6 per 100.

(9) *Cost of landing air-dried internodes per ton at the factory site.*

The cost of landing dry internodes at Bomanhalli, therefore, works out to Rs. 8-6 per ton and at Hubli at Rs. 13-1 per ton. Were the nodes to be taken into account, the rate would be reduced by 15 per cent.

(10) *Labour.*

Cooly labour will undoubtedly be a difficulty in this locality. It is obtainable, in limited quantities, at 5 to 7 annas a day for men and 2½ to 3 annas for women, who, in these parts, are hardworking. It would undoubtedly be necessary to import labour either from the coast or from the neighbouring Deccan districts.

(11) *Chemicals.*

Good limestone rock occurs at Churanhukli about 12 miles north-west of Yellapur and about 15 miles from Bomanhalli. Shell-lime is also procurable in large quantities on the coast at a distance of 70 miles. The other necessary chemicals will have to be imported.

(12) *Firewood.*

Fairly large quantities of fuel are always available from these forests and would contribute largely to supply a mill at Bomanhalli. At Hubli it would be necessary to use coal.

(13) *Miscellaneous facts.*

Most of the roads in this locality are metalled, and therefore extraction by cart is possible practically throughout the year. This is not the case when floating is employed as in the Gangavalli and Kala Nadi areas, where the rivers are low in April and May.

The climate of this tract of forest is, on the whole, better than in the two previous areas dealt with, while, as far as the factory sites are concerned, Hubli is preferable to Bomanhalli in this respect. The difficulty will be in obtaining sufficient labour, to which point careful attention will have to be paid before any steps are taken to establish a mill.

POSSIBLE SITES FOR BAMBOO PAPER-PULP MILLS IN THE MADRAS PRESIDENCY.

AREA NO. I. (*See portions marked D on map.*)

The Uppinangadi and Puttur bamboo areas in the South Canara Forest Division of the Madras Presidency.

(1) *Name and Situation.*

These forests are situated in the Uppinangadi Taluka of the South Canara Collectorate, some 60 miles inland from Mangalore, and a few miles short of the foot of the Western Ghats. The distance from the centre of the area to the sea is 60 miles. Down the Netravati river to Panimangalore is 40 miles, to which place sailing boats of five tons burden ply daily from Mangalore. The forests are drained in the north and centre by the Netravati river and its tributaries, the Kumardhari and by the Payaswani river in the Puttur Range. (See map.)

(2) *Description of the forests.*

The areas included in this scheme contain moist and dry deciduous forests with patches of evergreen, and are not dissimilar in character to those found in the neighbouring forests of North Kanara in the Bombay Presidency. In places the bamboo growth is not heavy but, in others, especially along small water-courses and in depressions, it is extremely fine and luxuriant.

(3) *Areas of forests covered with bamboos.*

The areas directly taken into consideration in this scheme lie in the Uppinangadi and Puttur Ranges, though mention will hereafter be made of other areas which might also be added and from which raw material could be obtained. The forests now under consideration are made up

of 15 blocks, most of which have no connection one with another, being divided from each other by narrow strips of revenue land.

	Blocks.	Area in acres.	
Uppinangadi Range.	1. Nerinkamale	3,894	
	2. Porkala	4,558	
	3. Shibage	3,456	
	4. Kadambila	1,848	
	5. Konage	6,642	
	6. Padnur	3,900	
			24,298 acres
Puttur Range.	7. Sampaji	5,120	
	8. Pumale	960	
	9. Purappa	1,920	
	10. Kankamajulu	640	
	11. Jalsur W.	960	
	12. Jalsur E.	160	
	13. Anegundi	640	
	14. Kaniarmale	500	
	15. Denachalla	600	
			11,500 acres.
	Total		35,798 acres.

(4) *Species of bamboo and mode of growth.*

By far the greater *portion* of the bamboo forest consists of *Bambusa arundinacea*, which, on the upper slopes of the low hills, is found growing 30 to 40 feet in height, while in the moister and lower areas it grows 70 to 80 feet in height, with a mean mid-girth of 8″. The Working-Plan Officer enumerated 426 acres in the various blocks which go to form the Uppinangadi Range and found 12·8 clumps of bamboo per acre, averaging 10 culms per clump. *Dendrocalamus strictus* bamboo also occurs in the forests, but only in small quantities.

(5) *Possible factory site.*

The most suitable site for a mill would be Panimangalore on the Netravati river (see map). Another possible site would be Mangalore, on the sea, but fuel and labour are more expensive at that port than further up the river. As regards water, a plentiful supply is available throughout the year from the river at Panimangalore.

(6) *Outturn.*

Mr. Foulkes, the Working-Plan Officer, when making the Working-Plan for these forests, enumerated bamboos over 426 acres, by taking sample plots scattered over each block. In these enumerations, he counted all the bamboo clumps in the area, but did not count the number of culms per clump, which has been put at the low estimate of 10 culms per clump. Based on these figures, which should be a very fair guide, the following calculation has been made :—

Name of Range.	Name of block	Area in acres.	Average area of sample plot taken by the Working-Plan Officer, in acres.	Average number of clumps per acre.	Number of bamboos in the whole area, taking 10 culms per clump.
Uppinangadi.	Nerinkemale.	3,894	101·7	12·07	467 280
	Porkala	4,558	121·1	10·92	501,380
	Shibago	3,456	82·6	16·95	584,064
	Kadambila	1,848	35·0	5·74	105,336
	Konago	6,642	86·0	13·35	883,386
	Padnur	3,900	*Nil*	10·0*	390,000
Puttur.	Sampaji	5,120	Do.	12·0	614,400
	Pumalo	960	Do.	10·0	96,000
	Purappa	1,920	Do.	8*	153,600
	Kankamajulu	640	Do.	8*	51,200
	Jalsur W.	960	Do.	8*	76,800
	Jalsur E..	160	Do.	8*	12,800
	Anegundi	640	Do.	6*	38,400
	Kaniarmale	500	Do.	8*	40,000
	Denachalla	600	Do.	8*	48,000
		35,798	426·4	*Estimated	4,062,346

Working on a five-year rotation we arrive at a sustained annual yield of 812,629 bamboos.

Now, from the enumeration of a sample plot in Nerankimale (see Appendix VI), the yield from 140 culms found on one acre was 6, 550 lbs. of dry internodes or, in round figures, 47 lbs. per culm. The annual sustained yield of dry internodes working on a five-year rotation, therefore, works out at 38,193,563 lbs. or 17,051 tons.

It was mentioned elsewhere that other areas might be tapped to supply the factory at Panimangalore with bamboos. Mr. Barry, the Divisional Forest Officer, suggests that bamboos could be floated down the Paishwani river, from the forests it drains, to Kasargad, be railed to Mangalore and taken up the Netravati river to Panimangalore. Were the erection of a mill contemplated at this spot, the possibility of utilizing this source of supply also would have to be duly considered.

(7) *Lines of export.*

A metalled road runs from Mangalore to Manjrabad, passing through the Uppinangadi range and taps the six blocks under consideration, while the Bisli Ghat road runs on the south side of the Padnur block. The average distance over which bamboos would have to be carted to Valol, on the Netravati river, is 15 miles, and the distance over which they will have to be floated from Valol to Panimangalore is 20 miles.

There are two possible ways of exploiting the bamboos from the nine blocks in the Puttur Range. One is by carting them down the Mangalore-Mercara main road and by the Jalsur-Subramania road, an average distance of 40 miles, the other by floating them down the Kumardhari river *via* Uppinangadi to Panimangalore. The river, however, is bad for floating, being full of rapids and boulders. The only way of improving it would be by carrying out fairly extensive blasting operations and by erecting temporary dams, so as to regulate and train the stream. Some three miles above the junction of the Netravati and Kumardhari rivers at Uppinangadi, there is, on the latter river, a low waterfall, which was inspected with a view to ascertain the possibility of utilizing the water-power and finding out if it formed an obstruction to possible floating operations. The river here is very broad, so that extensive works would have to be carried out to utilize the water for power, while it was found that the main channel was sufficiently broad to allow of rafting operations being carried out.

The river from Uppinangadi to Panimangalore is also full of boulders and shallows, though, no real difficulties occur to prevent floating from September to the end of January. After January, the river runs low and rafts containing over 40 bamboos are difficult to manage.

(8) *Cost of cutting and extraction.*

The cost of cutting and exploiting 100 bamboos from the Uppinangadi forests to Panimangalore works out as follows :—

	R.	a.	p.
1. Cost of cutting 100 bamboos	6	0	0
2. ,, ,, dragging to road	2	0	0
3. ,, ,, carting 15 miles to Valol at 2 annas a mile for 3 carts containing 33 bamboos each	5	10	0
4. ,, ,, toll on 3 carts at 4 annas each	0	12	0
5. ,, ,, floating from Valol to Panimangalore	2	0	0
	16	6	0

The cost of exploting 100 bamboos from the Puttur Range works out as follows :—

	a.	p.
1. Cost of cutting 100 bamboos	6	0	0
2. ,, ,, dragging to road	2	0	0
3. ,, ,, carting 40 miles at 2 annas per mile taking 33 bamboos and including toll	15	12	0
	23	12	0

The weight of 100 air-dried bamboos is 5,803 lbs. (see Appendix VI), so that the cost of landing one ton of air-dried bamboos at Panimangalore from the Uppinangadi forest comes to Rs. 6-6 and from the Puttur forests Rs. 9-4 per ton.

(9) *Cost of landing air-dried internodes per ton at factory site.*

From Appendix VI, it will be seen that the dry nodes are, in round figures, 20 per cent. by weight of the entire culms, so that the cost of landing dry internodes from Uppinangadi at Panimangalore works out at Rs. 7-10-6 and from Puttur at Rs. 11-13 per ton. On the other hand, if the nodes are also utilized, these figures must be reduced by 20 per cent. for this locality.

(10) *Labour.*

Cooly labour is fairly plentiful, though some may have to be imported for working in the mill. The wages earned by men are from 4 to 6 annas per day and women $2\frac{1}{2}$ to 3 annas. Good carpenters and masons are available in Mangalore at 12 annas to Re 1 a day. Carts are fairly plentiful but, were bamboos to be carted in large quantities from the Puttur forests, more carts would have to be introduced.

(11) *Firewood.*

Firewood is very plentiful in these forests, and the demand comparatively small. Its price is from Rs. 3 to Rs. 4 per ton at Uppinangadi and Rs. 6 per ton at Panimangalore.

(12) *Chemicals.*

Shell-lime is available in large quantities on the coast: it is sold in bags of 160 lbs. each, and the price of 100 such bags is Rs. 28.

The Bombay Steam Navigation Company's steamers call at the port of Mangalore, so that the cost of importing the necessary supplies, chemicals and fuel by sea should not be excessive. The terminus of the Madras Railway is situated at Mangalore, by which chemicals could be imported when steamer traffic is stopped during the monsoon.

(13) *Miscellaneous facts.*

The site chosen for the factory at Panimangalore is, generally speaking, a healthy one, the country being open and flat. The forests from which the bamboos can be exploited are feverish just after the rains. The coast rivers are, generally speaking, more silted up in this district than is the case in North Kanara, which is probably due to the excessive denudation of all tree-growth on the waste lands. For this reason, the streams are shallower, rendering navigation more difficult, and at the same time, rendering the rivers more liable to excessive floods in the monsoon.

AREA NO. II. (*See portion marked* ***E*** *on map.*)

The Kanoth bamboo forests of the North Malabar Forest Division of the Madras Presidency.

(1) *Name and Situation.*

These forests are situated in the Kottayam Taluka of the Malabar Collectorate, some 20 miles inland from the seaport of Tellicherry and directly below the Wynaad forests of the Western Ghats. To the south of the bamboo area runs a small stream, known as the Edayer, the northern limit being the Tellicherry-Manantoddy high road.

(2) *Description of the forests.*

The area covered with bamboos is extremely limited, so that, were a mill to be erected and supplied from this area, it would necessarily have to be run on a small scale. The forests containing the bamboos lie in the valley of the Edayer (see map) and though forests extend up the range of hills to the south, and also cover the Western Ghats to the east, they contain but few bamboos. On the more level ground, to the south of the main road and extending up the valley to Nedumboil Chuttram, the bamboo growth is in many places extremely fine, and some of the culms exceed in size and weight any stems of this species weighed elsewere.

(3) *Area of forest covered with bamboos.*

The total area of the block is 19,018 acres ; of this, the forests lying in the valley cover some 3,000 acres and are densely stocked with bamboos. The rest of the area contains semi-moist-deciduous forest, in which bamboos occur, but only scattered here and there in small quantities.

(4) *Species of bamboos and mode of growth.*

The prevailing species is *Bambusa arundinacea* and therefore the same as that prevailing throughout the entire length of the Western Ghats. It forms in these forests very fine clumps, containing many large culms. The average length of 200 cut stems was 56½ feet and 10·7″ mid-girth, representing a length of about 10 feet and a girth of 2″ in excess of any

previously recorded. The other species found in these forests is *Dendrocalamus strictus*, a small strong bamboo, the demand for which in the market is already equal to, if not greater than, the possible outturn, so that from the point of view of pulp-making it may be neglected. There exists to the south of the main road, and some three miles from the Travellers' Bungalow, a bamboo plantation in which several exotics, chiefly from Burma, have been introduced and which have done remarkably well. The area of the plantation is, however, of insufficient size, to be of any real importance, except to demonstrate the possibility of cultivating such species in this locality.

(5) *Possible factory site.*

It is not easy to fix on a suitable site for a factory. The best place would probably be above the village of Kuttaparamba, in the Edayer creek, at a point a little above that at which the tide makes itself felt. To ensure a sufficient supply of fresh water for the mill, it would be necessary either to dam the river or prepare storage tanks, otherwise there would be insufficient water from February onwards till the monsoon sets in. The distance of the proposed site is 12 miles from the centre of the bamboo area and 8 from the Railway station of Tellicherry, both places being on the Tellicherry-Manantoddy high road, which also passes through the bamboo area. The proposed site is by no means an ideal one, though the best which could be found.

(6) *Outturn.*

The area from which bamboos can be exploited is small, though this defect is in a measure compensated for by the heavy crop. From Appendix VI, it will be seen that the average outturn of dry internodes is 29,909 lbs. per acre or 13·3 tons, which gives a gross yield of 39,900 tons, or by cutting on a five-year rotation a sustained yield of 7,980 tons of dry internodes per annum. In the above calculation, only the area which is densely covered with bamboos has been taken into account, so that the figure of sustained yield, which might be augmented by fellings in the other portions of the block, may be taken as a low estimate.

(7) *Lines of export.*

A small river, named the Edayer, which is about 20 yards broad at Kanoth, runs down the south boundary of the bamboo area. Along the

north side, running the whole length of the area, is the Tellicherry-Manantoddy metalled road. Along this road, the gradients, within and below the bamboo area, are nowhere steep, so that loaded carts can be moved along it without difficulty. The stream is not really suitable for floating bamboos, though it could be utilized for the purpose during the months of August, September and October. The Southern India Railway runs through Tellicherry, northwards along the coast to Mangalore and southwards to Calicut.

(8) *Cost of cutting and extraction.*

It has been mentioned above that bamboos will have to be transported from the forest to the mill by carts. They will also have to be dragged from the forest to the road, a distance which will rarely exceed a mile. Under these conditions the cost of landing air-dried bamboos, from the centre of the area to Kuttaparamba, works out as follows :—

	R.	*a.*	*p.*
1. Cost of cutting 100 bamboos	6	0	0
2. ,, ,, carting at 4 annas per mile, over 12 miles, and 20 bamboos per cart	15	0	0
3. ,, ,, dragging to road	2	0	0
Total .	23	0	0

The reason why the estimated number of bamboos per cart has been put as low as 20 is that the average dry bamboo with nodes weighs as much as 63 lbs. so that 20 weigh about $\frac{1}{2}$ ton which is the capacity of cart over a good road.

(9) *Cost of landing air-dried internodes per ton at the factory site.*

From Appendix VI it will be seen that the dry nodes make up 16 per cent. of the total weight of a dry bamboo. Now the average weight of 100 air-dried bamboos is 6,370 lbs. or 63·7 lbs. per bamboo, of which 10·2 lbs. is the weight of the nodes. It, therefore, takes 42 bamboos to make up one ton of dry internodes. It costs Rs. 23 to land 100 such bamboos at the mill, so that one ton of dry internodes will cost Rs. 9-10-6 per ton at Kuttaparamba.

(10) *Labour.*

Cooly labour is not available in large quantities, and will certainly have to be imported from the coast villages. The usual wages for men is 4 to 6 annas per day, according to the season. Skilled labour, such as carpenters and masons, is available from Tellicherry, failing which it could be procured from Mangalore or Calicut. The supply of carts is also insufficient and will have to be augmented by supplies from other parts.

(11) *Firewood.*

Firewood is available in considerable quantities from the neghbouring forests and possibly from the Ghat forests above the bamboo area, though the labour to collect it and the carts with which to transport it to the mill will not be sufficient unless more are introduced into the district. Coal is available on the railway, though its price is high, the area being far from the coal-fields. The question of fuel is therefore one which will require careful attention.

(12) *Chemicals.*

Shell-lime is procurable on the coast at about 12 annas per cwt. The other chemicals can be imported cheaply by sea or failing that line of supply in the monsoon, they can be railed to Tellicherry and carted to the mill, a distance of 8 miles.

(13) *Miscellaneous facts.*

The site selected for the factory is not unhealthy. The difficulty does not appear to lie in this direction but in the labour question, the cost of fuel and possibly the water-supply, all of which points will require careful consideration before coming to any decision as to the advisability of erecting a pulp-mill in this locality.

AREA NO. III. (*See portions marked* ***F*** *on the map.*)

The Nilambur and Amarampalam Bamboo areas of the South Malabar Forest Division of the Madras Presidency.

(1) *Name and Situation.*

These forests are situated in the Nilambur and Amarampalam Ranges of the South Malabar Division, in the open valley formed by the Chaliar

river and its tributaries, some 50 miles from the sea and stretching 8 to 9 miles above the village of Nilambur. The river Chaliar finds its way from the slope of the Nilgiris, passing in its upper reaches through the bamboo and teak forests above mentioned, to the sea at Calicut.

(2) *Description of the forests.*

The forest areas lie on the slightly undulating ground to the north of the Chaliar river (see map) and comprise moist-deciduous forest, in which extensive clearings have been made and on which has been created the famous Nilambur teak plantation. The growth of bamboos, where such clearings have not been carried out, is generally dense, the culms being often of enormous size. To the south of the river lie private forests, also well stocked with bamboos.

(3) *Area of forest covered with bamboos.*

In computing the area covered with bamboos, those covered with plantations have not been taken into account. Though no enumeration was made in the Private Forests to the south of the river, they may also be taken into account in this scheme, as it is understood that they would also be available for the supply of bamboos.

The following figures of areas have been taken from the Working-Plan prepared for these forests :—

	Name of Block.	Area.
Nilambur Range	Vellachapally	623 acres.
	Pokode	508 ,,
	Kanakutha	668 ,,
	Chattawbaria	215 ,,
	Valluvasheri	204 ,,
	Panayangote	..
	Eranbaden	282 ,,
	Eddakode	580 ,,
		—— 3,080 acres.
Amarampalam Range	Kallikutta	..
	New Amarampalam	2,500 acres.
	Private Forests	3,800 ,,
		—— 6,300 acres.
	GRAND TOTAL	9,380 acres.

(4) *Species of bamboos and mode of growth.*

The species is the same as elsewhere on the West Coast, being *Bambusa arundinacea*, the culms of which are large and many of which go to form a clump. In the first seven blocks mentioned in the above list, the bamboo growth is dense, while the forests of the Amarampalam Range and the Private Forests to the south of the river, are fairly well stocked with bamboos. The palisade of thorny branches, of which mention has been made elsewhere, is even heavier round the clumps in these forests than is the case in the forests of North Malabar and in Kanara.

(5) *Possible factory site.*

The most suitable factory site is probably near the village of Chaliapuram, situated on the Chaliar river, 24 miles from the sea, and above tidal level. The longest line, along which floating from the reserves would have to be carried out, is 26 miles. Chaliapuram has the advantage of being so situated that five-ton sailing boats can reach it from Calicut at all times of the year, that the bamboos can be floated down without difficulty to the mill from the forest, and that there is a plentiful supply of fresh water available. Were the mill to be erected at Calicut, which is more central and on the railway and also a seaport there might be difficulty in obtaining a sufficient supply of fresh water. It is true that the cost of importing the chemicals might be reduced by placing the mill at the seaport of Calicut, but, on the other hand, the cost of transporting them to Chaliapuram in sailing boats would be relatively small.

(6) *Outturn.*

The possible outturn is based on the enumerations made in these forests (see Appendix VI). Owing to the limited time available, only two sample plots were taken, so that, for the forests in the Amarampalam Range and in the Private Forests, which were inspected and found to contain rather less bamboos than in the forests where enumerations were made, a 20 per cent. reduction has been adopted. The average outturn of dry internodes is 25,544 lbs. or 11·4 tons per acre. The area of the fully-stocked bamboo forest is 3,080 acres and that of fairly-stocked forest, to be calculated on a 20 per cent. reduction or at 9·1 tons per acre. is 6,300 acres. The gross yield of dry internodes, therefore, works out for

both areas together, at 92,442 tons. Cutting on a five-year rotation, the sustained supply of air-dried internodes comes to 18,488 tons per annum. These figures, as elsewhere explained, may be raised by 16 per cent. if the nodes are taken into account.

(7) *Lines of export.*

Bamboos can be floated down the main stream of the Chaliar river throughout the year, and down its tributaries from July to November. The longest distance over which floating will have to be carried out from the forests of Nilambur and the Private Forests, to a mill at Chaliapuram, is 26 miles.

From the forests of the Amarampalam Range, the bamboos will have to be floated down the Karimpoya river and its tributaries, the former being a large tributary of the Chaliar river, the junction of the two streams occurring just above the village of Nilambur. Floating is possible down one tributary of the Karimpoya from as far up as the village of Nedamgam and also from up another tributary of the same river to Nellinkutta, so that the extreme distance, over which bamboos would have to be dragged or carted from the forests of Amarampalam to a floating stream, would be 4 to 5 miles. From that point, they can be floated down to the proposed mill site without difficulty.

The Chaliar river is also available as a means of communication with Calicut as sailing boats come up to Chaliapuram throughout the year. Calicut is also a seaport and at Kalai, 3 miles from Calicut, exists a station of the South Indian Railway, close to a navigable branch of the river.

(8) *Cost of cutting and extraction.*

The cost of felling and extraction from the Nilambur and Private Forests works out as follows :—

	R.	*a.*	*p.*
1. Cost of cutting 100 bamboos	6	0	0
2 ,, ,, dragging to floating stream, an average distance of one mile	2	0	0
3. ,, ,, floating to factory site	2	0	0
	10	0	0

Cost of extraction from the forests of the Amarampalam Range:—

	R	a.	p.
1. Cost of cutting 100 bamboos	6	0	0
2. ,, ,, carting or dragging 5 miles to a floating stream, a cart taking 20 bamboos, at 4 annas per mile	6	4	0
3. ,, ,, floating 30 miles to mill	2	12	0
	15	0	0

(9) *Cost of landing air-dried internodes per ton at the factory site.*

From Appendix VI, it will be seen that the dry nodes make up, in round figures, 14 per cent. of the dry culms. To this figure 2 per cent. should be added for loss in sawing, or a total of 16 per cent. should be deducted from the total weight of the bamboos in order to arrive at the weight of the dry internodes. From the same statement it will be seen that a dry culm weighs 72 lbs. or after deducting the weight of the nodes 60·5 lbs. It therefore requires 37 culms to produce a ton of air-dried internodes. The cost of landing one ton of dry internodes at the mill site, therefore, works out to Rs. 3-11-2 per ton from the Nilambur and Private Forests and Rs. 5-8-10 per ton from the forests of the Amarampalam Range. Provided the nodes are also treated, the cost of extraction would be reduced by 16 per cent.

(10) *Labour.*

Cooly labour is fairly plentiful along the coast and could be imported at 6 annas per day. Carts cost 4 annas per mile and will carry up to 6 cwts. Masons and carpenters are available in Calicut at about Re. 1 per day. The same labour difficulties, which were anticipated in the case of Kanoth, should not occur in Nilambur.

(11) *Firewood.*

Firewood is fairly plentiful at Nilambur and, it is estimated, would cost Rs. 4 to Rs. 5 per ton at Chaliapuram, exclusive of royalty. The yield is roughly estimated at 2,000 tons per annum.

(12) *Chemicals.*

Shell-lime is available in fairly large quantities along the coast, and costs about Rs. 13 per ton or Rs 14 per ton at the mill. The other

chemicals necessary would have to be imported by sea, their prices at Calicut and Bombay being approximately the same, if imported from Europe.

(13) *Miscellaneous facts.*

The place proposed for the mill is a healthy spot as compared with many similar localities on the West Coast. Nilambur has also not a bad reputation, it being the head-quarters of the Divisional Forest Officer of South Malabar. The proposed mill site presents several advantages over the other places, which have been dealt with in Madras, in that, it lies on a large river, so that not only can bamboos be floated down during the greater part of the year, but also it is in direct communication by sea and railwith the outside world.

PART V—PLANT.

COST OF PLANT REQUIRED FOR A MILL.

It is not possible, for want of space, to give more than one or two estimates of cost of plant, and those given are only intended to show approximately what it would cost to erect a large pulp-mill. Those interested in the subject will no doubt obtain their estimates after having decided on the proposed capacity of the mill.

Sindall's estimate for a mill.—Mr. R. W. Sindall in his booklet on "Bamboos for paper-making" of 1909 (Marchant, Singer & Co., 47, St. Mary Axe, E. C., London) gives the cost of a mill with a weekly output of 200 tons of bleached bamboo-pulp, working with caustic soda, as follows:—

	£
Estimated approximate cost of plant	20,000
Buildings and foundations	12,000
Contingencies	4,000
Total	36,000

James Bertram & Sons' estimate for a mill.—Various estimates by firms in England and America are available. The following is one kindly sent by James Bertram & Sons, Limited, of Leith Walk, Edinburgh.

A mill is designed to produce about 20 tons of air-dried unbleached bamboo-pulp per day of 24 hours, working by the soda process.

Approximate cost of the machinery, all delivered f. o. b. Glasgow, £15,500 including steam and power plant. Approximate weight 600 tons; to the above estimate will have to be added cost of buildings, etc., which will vary according to the locality in which they are erected.

Estimate put up by Lounsbery Bros. of Chicago.—Another estimate is available from America, which was sent by Lounsbery Bros. & Co., of 305, Dearborn St., Chicago. The estimate, which was made in dollars,

has been converted into pounds sterling. The figures for a Soda-Pulp-Mill estimated to turn out 10 tons of bleached pulp per 24 hours are :—

	£
Buildings	5,800
Add—10 per cent.	580
	6,380

Equipment.

	£
Power House plant	3,900
Boiler ,, ,,	1,400
Wood Preparing room	220
Digester Building room	1,700
Pulp Washing	1,420
Screen and Wet Machine room	1,140
Incinerator room	1,020
Leaching ,,	720
Evaporating ,,	1,600
Causticizing ,,	840
Miscellaneous	2,400
	16,360
Add—10 per cent.	1,636
	17,996

Summary.

	£
Buildings	6,380
Equipment	17,996
	24,376

A further estimate is given by this Company for a mill working by the sulphite process, with an outturn of 10 tons of unbleached pulp in 24 hours. It reads as follows :—

	£
Buildings	5,380
Add—10 per cent.	538
	5,918

Equipment.

	£
Power House plant	3,800
Boiler	1,400

	£
Wood Preparing plant	240
Digester Building plant	1,600
Blow Tank room	440
Sulphur Burner	140
Acid making plant	1,820
Screen and Wet machine	1,120
Sulphur storage and lime mixing room	150
Miscellaneous	2,200
	12,910
Add—10 per cent.	1,291
	14,201

Summary.

	£
Buildings	5,918
Equipment	14,201
	20,119

The cost of the buildings is based on American figures and would therefore have to be adapted to Indian conditions.

Estimate by the Stebbins Engineering and Manufacturing Co.—Another estimate is made by the Stebbins Engineering and Manufacturing Co., 74-78, Smith Buildings, Watertown, New York, for a Soda Plant, which is capable of turning out $8\frac{1}{2}$ tons of dry pulp per day; cost, including materials and buildings as applied to America, £18,000.

PART VI.

CHEMICALS AVAILABLE AND THEIR COST.

(1) *Lime.*

Price of lime.—Lime, which is a very important factor, is procurable in or near all the places which have been proposed as possible mill sites.

In Burma lime can be purchased in Rangoon at annas 5 per cubic foot, it being procured from Moulmein, Kyanksé and Toungoo. In Pyinmana locally prepared lime costs 8 annas per 100 lbs. In Arakan coral-lime sells at 14 annas per cwt., being obtained from Kyanksé.

On the West Coast excellent shell-lime costs 12 annas per cwt.

(2) *Caustic soda.*

Price of Caustic soda.—It will be necessary to import caustic soda from Europe.

The price paid now by Indian mills varies from Rs. 150 to Rs. 165 per ton. In 1898, the price *ex*-ship Calcutta was as high as Rs. 174 per ton, while Sindall's figure in Rangoon for 1906 was Rs. 159 per ton.

(3) *Sulphur.*

Prices of Sulphur.—The following are the prices for 1909 quoted by the Collectors of Customs, Calcutta, Madras, Karachi and Bombay :—

	Roll sulphur, per ton *ex*-ship.	Rough sulphur, per ton *ex*-ship.
	R a. p.	*R a. p.*
Calcutta . . .	93 13 0	92 8 0
Madras	..	89 12 0
Karachi	93 4 0	84 4 0
Bombay . . .	91 8 0	..

Sindall in his report quotes the prices of sulphur from Sicily landed in Rangoon in 1906 at Rs. 99-12 per ton.

(4) *Bleaching powder.*

Price of Bleaching powder.—The relatively high cost of Bleaching powder makes it absolutely necessary that the percentage of bleach utilised should not exceed 12 per cent. of the weight of the raw material in a dry state. The price landed in Calcutta in 1911 was Rs. 125 per ton; in Rangoon the price would be slightly higher and in Bombay slightly less.

(5) *Soda ash, China clay and Alum.*

Price of Soda ash.—The price of Soda ash in Calcutta is about Rs. 100 and in Rangoon Rs. 110 per ton c. i. f.

Price of China clay.—The price of China clay in Calcutta is about Rs. 45 per ton c. i. f.

Price of Alum.—The price of Alum in Calcutta is about Rs. 100 per ton c. i. f.

(6) *Coal.*

Coal is procurable in large quantities from the Raneegunge Coal Fields in Bengal. The price fluctuates enormously: in 1909, it was about Rs. 3 at the pit mouth and as much as Rs. 10 per ton in Calcutta, while Sindall's figure for Rangoon is Rs. 15 per ton. In Bombay the cost of coal comes to Rs. 15 to Rs. 18 per ton.

(7) *Freight.*

Freight of bamboos.—Freight rates by sea vary from time to time, so it is not possible to give figures of any great value; they can, however, always be obtained from large shipping agents.

Freights quoted by the Agent for Government Consignments, Calcutta, for bamboos from Rangoon to Calcutta, are as follows:—

Steamer freight Rs. 10 per ton of 50 cubic ft.

Port and shipping charges Rs. 2-4 per ton.

Freight for Chemicals.—Freight of Chemicals, from Liverpool to Calcutta, varies from Rs. 20 to Rs. 25 per ton; and to Rangoon, Rs. 22-8 to Rs. 26 per ton.

APPENDICES.

APPEN

Experimental Bamboo Sample Plots in the

(These figures refer to the Hlaing Yoma,

Locality.	Area of sample plot, in acres.	Type of Forest.	SPECIES.						NUMBER OF EXPERIMENTAL STEMS CUT.	
			CEPHALOSTACHYUM PERGRACILE (*Tinwa*).			BAMBUSA POLYMORPHA (*Kyathaung*).				
			Number of clumps counted.	Number of new stems counted.	Number of old stems counted.	Number of clumps counted.	Number of new stems counted.	Number of old stems counted.	Cephalostachyum pergracile (*Tinwa*).	Bambusa polymorpha (*Kyathaung*).
Compartment 28, Hlaing Yoma Reserve, Rangoon Division.	1	Teak and bamboo forest.	191	685	1,995	5	30	81		
Compartment 61, Yindaik Forest, Okkan Reserve, Rangoon Division.	1	Ditto	173	224	1,125	56	162	415	100	100
Ditto Ditto .	1	Ditto	119	198	668	79	230	582		
Ditto ditto .	1	Ditto	196	452	1,397	29	83	176		
Compartment 76, Wèywa Forests, Thonzé Reserve, Tharrawaddy Division.	1	Ditto	38	76	182	71	259	595		
Compartment 70, Wèywa Forests, Thonzé Reserve, Tharrawaddy Division.	1	Ditto	81	126	385	59	226	469		
Compartment 62, Wèywa Forests, Thonzé Reserve, Tharrawaddy Division.	1	Ditto	145	260	1,000	28	61	255		
Ditto ditto .	1	Ditto	96	178	536	72	242	671	100	100
Compartment 63, Wèywa Forests, Thonzé Reserve, Tharrawaddy Division.	1	Ditto	79	118	355	82	260	647		
Ditto ditto .	1	Ditto	135	205	702	63	145	419		
TOTAL .	10	..	1,253	2,522	8,345	544	1,698	4,310	200	200
Average	1	..	125	252	834	54	170	431	Average of one stem.	

NOTE 1.—New stems are those which have come into existence in one monsoon but have not

DIX I.

Rangoon and Tharrawaddy Forest Divisions of Lower Burma.

Okkan and Thonzé Bamboo areas.)

AVERAGE SIZE OF ONE STEM.				TOTAL WEIGHT OF GREEN STEMS, IN LBS.						TOTAL WEIGHT OF DRY INTERNODES, IN LBS.		YIELD OF DRY INTERNODES, IN LBS. PER ACRE.		
CEPHALOSTACHYUM PERGRACILE (*Tinwa*).		BAMBUSA POLYMORPHA (*Kyathaung*).		CEPHALOSTACHYUM. PERGRACILE (*Tinwa*).			BAMBUSA POLYMORPHA (*Kyathaung*).							
Length in feet.	Mid-girth in inches.	Length in feet.	Mid-girth in inches.	Internodes.	Nodes.	Total.	Internodes.	Nodes.	Total.	Cephalostachyum pergracile (*Tinwa*).	Bambusa polymorpha (*Kyathaung*).	Cephalostachyum pergracile (*Tinwa*).	Bambusa polymorpha (*Kyathaung*.)	Total in lbs. per acre.
27·6	5·9	32·8	8·8	1,098	147	1,245	2,039	315	2,354	840	1,414	8,254	9,255	17,509
28·6	5·6	33·6	8·9	862	211	1,073	2,228	404	2,722	674	1,670			
56·2	11·5	66·4	17·7	1,960	358	2,318	4,267	809	5,076	1,514	3,084	..	..	
28·1	5·7	33·2	8·8	9·8	1·8	11·6	21·3	4·1	25·4	7·6	15·4	8,254	9,255	17,509

Passed through a second rains. Old stems are those which have passed through two or more rainy seasons.

APPEN

Experimental Bamboo Sample Plots in the Toungoo and

(These figures refer to the Pyinmana and

Locality.	Area of sample plot, in acres.	Type of Forest.	SPECIES.						NUMBER OF EXPERIMENTAL STEMS CUT.	
			CEPHALOSTACHYUM PERGRACILE (*Tinwa*).			BAMBUSA POLYMORPHA (*Kyathaung*).				
			Number of clumps counted.	Number of new stems counted.	Number of old stems counted.	Number of clumps counted.	Number of new stems counted.	Number of old stems counted.	Cephalostachyum pergracile (*Tinwa*).	Bambusa polymorpha (*Kyathaung*).
*Compartment 104 (on banks of the Kabaung river), Toungoo Division.	5*	Teak and bamboo.	..	..	..	235	752	3,915	..	..
*Compartment 104 (on slopes above the Kabaung), Toungoo Division.	1·7*	Ditto	..	..	..	146	204	2,432	..	..
*Compartment 11 (on upper slopes), Bondaung Reserve, Toungoo Division.	0·9*	Ditto	..	..	..	80	170	1,267	..	..
* Ditto ditto .	1·1*	Ditto	..	..	..	93	192	1,207	50	60
* Ditto ditto .	1·6*	Ditto	..	..	..	127	266	2,231	..	..
Compartment 16, Yanaungmyin Reserve, Pyinmana Division.	1	Ditto	..	..	..	112	479	1,212	150	140
Compartment 8, Yanaungmyin Reserve, Pyinmana Division.	1	Ditto	13	14	53	97	313	1,261		
Compartment 19, Yanaungmyin Reserve, Pyinmana Division.	0·5	Ditto	50	75	279	48	192	599		
Ditto ditto .	2	Ditto	530	1,012	2,144	36	203	637		
Compartments 15 and 19, Yanaungmyin Reserve, Pyinmana Division.	2	Ditto	212	424	1,049	65	412	1,562		
TOTAL .	16·8	..	805	1,525	3,525	1,039	3,183	16,323	200	200
Average for one acre . .	1	..	145†	277†	641†	62	189	971	Average for one stem.	

NOTE I.—Figures marked thus † are averages for

NOTE II.—Figures marked * are from enumerations made by

NOTE III.—New stems are those which have come into existence in one

DIX II.

Pyinmana Forest Divisions of Burma.

Toungoo Bamboo areas.)

AVERAGE SIZE OF ONE STEM.				TOTAL WEIGHT OF GREEN STEMS IN LBS.						TOTAL WEIGHT OF DRY INTERNODES, IN LBS.		YIELD OF DRY INTERNODES, IN LBS. PER ACRE.		
CEPHALOSTACHYUM PERGRACILE (*Tinwa*).		BAMBUSA POLYMORPHA (*Kyathaung*).		CEPHALOSTACHYUM PERGRACILE (*Tinwa*).			BAMBUSA POLYMORPHA (*Kyathaung*).							
Length in feet.	Mid-girth in inches.	Length in feet.	Mid-girth in inches.	Internodes.	Nodes.	Total.	Internodes.	Nodes.	Total.	Cephalostachyum pergracile (*Tinwa*).	Bambusa polymorpha (*Kyathaung*).	Cephalostachyum pergracile (*Tinwa*).	Bambusa polymorpha (*Kyathaung*).	Total in lbs. per acre.
..	..	53*	11*											
..	..	44*	11*											
..	..	..	..											
42	6·6	52	10·1	1,025	161	1,186	2,683	514	3,197	705	1,620	9,351	29,696	39,047
34	6·1	46	8·3	2,111	416	2,527	4,922	1,190	6,112	1,704	3,502			
76	12·7	195	40·4	3,136	577	3,713	7,605	1,704	9,309	2,409	5,122	..	..	..
38	6·3	49	10·1	15·7	2·9	18·6	38·0	8·5	46·5	12·05	25·6	9,351	29,696	39,047

5·5 acres.
Mr. Borie, Divisional Forest Officer, Toungoo.
monsoon but have not passed through a second rains. Old stems are those which have passed through two or more rainy seasons.

APPENDIX III.

Experimental Bamboo Sample Plot taken in the Arakan Forest Division of Lower Burma.

(These figures refer to the Seik, Kaladan and Lemru Bamboo Catchment areas.)

Locality.	Area of sample plot, in acres.	Type of Forest.	SPECIES. MELOCANNA BAMBUSOIDES. Number of culms.	Number of experimental stems cut on which the yield is based.	AVERAGE SIZE OF ONE STEM. Length in feet.	AVERAGE SIZE OF ONE STEM. Mid-girth in inches.	Total weight green, in lbs.	Total weight dry, in lbs.	Yield per acre, in lbs.	REMARKS.
Lemru Catchment area, Arakan Division.	1	Pure bamboo forest cut over 10 years ago for Taungya cultivation.	10,575	*10,575	22	3·8	27,404	16,576	16,576	The growth in the area in which the sample plot was cut, was slightly under the average.

*NOTE I.—All the bamboos were cut down over one acre and counted and weighed green and dry.

NOTE II.—This sample plot was taken by Mr. Walker, Divisional Forest Officer, Arakan.

NOTE III.—New stems are those which have come into existence in one monsoon but have not passed through a second rains. Old stems are those which have passed through two or more rainy seasons.

APPENDIX IV.

Experimental Bamboo Sample Plots taken in the North and West Kanara Divisions of the North Kanara Collectorate, Bombay Presidency.

APPEN

Experimental Bamboo Sample Plots taken in the North and West Kanara

(These figures refer to the Gangavalli,

Serial No.	Locality.	Area of sample plots, in acres.	Class.	Type of Forest.	SPECIES. BAMBUSA ARUNDINACEA. No. of clumps counted.	No. of new stems counted.	No. of old stems counted.	No. of experimental stems cut.
1	Compartment 45, Block XXV. Gangavalli Forests, West Kanara Division..	2	1st class bamboo area.	Moist deciduous forest with many *Bambusa arundinacea.*	90	291	872	100
2	Compartment 44, Block XXV. Gangavalli Forests, West Kanara Division.	1		Ditto ditto	45	112	224	52
3	Compartment 7, Block XXIV. Gangavalli Forests, West Kanara Division.	1		Moist deciduous with large clumps of bamboos.	110	206	335	102
4	Block XXV, Gangavalli Forests, West Kanara Division.	1		Ditto ditto	55	118	201	100
5	Compartment 70, Block XXIV. West Kanara Division.	1		Ditto ditto	68	149	284	50
6	Compartment 62, Block XXIV. West Kanara Division.	1		Ditto ditto	78	153	223	50
	Average per acre in 1st class area	1		..	64	147	306	Average of one stem.
7	Compartment 8, Block XXIV. Gangavalli Forest, West Kanara Division.	1	2nd class bamboo area.	Dry deciduous	86	113	178	50
8	Compartment 9, Block XXIV. Gangavalli Forest, West Kanara Division.	2·4		Ditto	46	165	242	50
	Average per acre in 2nd class area	1		..	39	82	124	Average of one stem.
9	Gund Forests, North Division, Kanara.	5		Moist teak and bamboo forest, the growth of bamboos very fine.	144	271	1,860	10
	Average per acre	1		..	29	54	372	Average of one stem.

NOTE I.—The figures arrived at by enumerations made in the Gangavalli Valley have also been utilized in calculating
NOTE II. —New stems are those which have come into existence in one monsoon but have not passed through a second

DIX IV.

Forest Divisions of the North Kanara Collectorate, Bombay Presidency.

Kala Nadi and Gund Slopes Bamboo areas.)

AVERAGE SIZE OF ONE STEM.		Total weight green, in lbs.	Total weight dry, in lbs.	Weight of dry internodes, in lbs.	Weight of dry nodes and saw-dust, in lbs.	Yield of dry internodes per acre, in lbs.	REMARKS.
Length in feet.	Mid-girth in inches.						
54	10·3	7,094	5,152	4,300	852	24,983	1st class bamboo forest above average.
48	9·2	3,269	2,359	1,975	384	12,762	1st class a fair average.
36	7·1	2,468	1,702	1,560	232	8,274	Ditto.
46	7·4	3,816	2,986	2,610	376	8,326	Ditto.
32	7·5	2,118	1,242	1,081	161	9,361	Ditto.
24	7·1	1,710	1,111	989	122	7,437	1st class but slightly below the average.
40	8·1	45	32	27	5	10,163	
25·2	5·9	670	528	452	76	2,631	A poor bamboo area.
42·2	7·7	1,435	1,064	895	169	1,320	A poor bamboo area on higher slopes.
33·7	6·8	21	15·9	13·5	2·4	1,975	
47	12·5	1,387	1,146	680	Not known.	28,968	
47	12·5	138·7	114·6	68·0	..	28,968	

the yield in the neighbouring valley of the Kala Nadi.
rains. Old stems are those which have passed through two or more rainy seasons.

APPEN

Experimental Sample Plots taken in the East Kanara Forest

(These figures refer to the

Locality.	Area of sample plot, in acres.	Type of forest.	SPECIES.			No. of experimental stems cut.
			BAMBUSA ARUNDINACEA.			
			No. of clumps counted.	No. of new stems counted.	No. of old stems counted.	
Mungod Forests, East Kanara Forest Division.	5	Dry deciduous bamboo forest.	404	429	3,239	100
Average per acre	1	.. ..	81	86	648	Average of one stem.

NOTE I.—These are the averages for 5 separate sample plots.
NOTE II.—These sample plots were taken by Mr. Butterworth, Assistant Conservator of Forests.
NOTE III.—New stems are those which have come into existence in one monsoon but have not passed

APPEN

Experimental Bamboo Sample Plots in the South Kanara and

(These figures refer to the Uppinangadi

Locality.	Area of sample plot, in acres.	Type of forest.	SPECIES.			No. of experimental stems cut on which the yield is based.
			BAMBUSA ARUNDINACEA.			
			No. of clumps counted.	No. of new stems counted.	No. of old stems counted.	
Compartment II, Coupe 4, Uppinangadi Range, South Canara Division.	2	Moist deciduous with many *Bambusa arundinacea.*	26	82	198	100
Average per acre	1	..	13	41	99	Average of one stem.
Kumari Forest, Kanoth Range, North Malabar Division.	1	Ditto	30	160	438	100
Ditto ditto . .	1	Ditto	50	170	331	100
Average yield per acre	1	..	40	165	384	Average of one stem.
Porkado Forest, Nilambur Range, South Malabar Division.	1	Ditto	45	125	287	100
Kanakatha Range, South Malabar Division.	1	Ditto	46	131	248	..
Average per acre	1	..	45	128	267	Average of one stem.

NOTE I.—The yield is not based on figures derived from these enumerations but on the enumerations
NOTE II.—New stems are those which have come into existence in one monsoon but have not passed

DIX V.

Division of the North Kanara Collectorate, Bombay Presidency.

Mungod Bamboo area.)

AVERAGE SIZE OF ONE STEM.		Total weight green, in lbs.	Total weight dry, in lbs.	Weight of dry internodes, in lbs.	Weight of dry nodes and saw-dust, in lbs.	Yield of dry internodes per acre, in lbs.	REMARKS.
Length in feet.	Mid-girth in inches.						
38	8·8	5·759	Not known.	3,720	Not known.	5,461	
38	8·8	57·6	..	37·2	..	5,461	

through a second rains. Old stems are those which have passed through two or more rainy seasons.

DIX VI.

North and South Malabar Forest Divisions of the Madras Presidency.

Kanoth and Nilambur Bamboo areas.)

AVERAGE SIZE OF ONE STEM.		Total weight green, in lbs.	Total weight dry, in lbs.	Weight of dry internodes, in lbs.	Weight of dry nodes, sawdust, etc., in lbs.	Yield of dry internodes per acre, in lbs.	REMARKS.
Length in feet.	Mid-girth in inches.						
55	10	8,765	5,803	4,679	1,124	6,550	Taken on undulating ground.
55	10	87·6	58	46·8	11·2	6,550	
61	11·1	12,525	7,867	6,487	1,380	38,792	Taken in moist deciduous bamboo forest, few new clumps.
51	10·3	7,472	4,873	4,197	676	21,026	A fair number of young clumps.
56	10·7	99·9	63·7	53·4	10·3	29,909	
63	10·2	10,995	7,206	6,200	1,006	25,544	Taken in heavy bamboo forest.
..	..	..	...	..	..	..	
63	10·2	109·0	72·1	62·0	10·1	25,544	

made by the Working-Plans Officer over an area of 426 acres.
through a second rains. Old stems are those which have passed through two or more rainy seasons.

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